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INDUSTRIAL DISTRICTS AND LOCALIZED TECHNOLOGICAL KNOWLEDGE: THE DYNAMICS OF CLUSTERED SME NETWORKING (INLOCO)

FINAL REPORT

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ABSTRACT

This report elaborates the notion of technological district building upon the notions of localized technological change and localized technological knowledge. It provides an explicit regional dimension to the production of localized technological knowledge and contributes the understanding of the determinants of regional concentration activities. On these basis a framework for regional innovation policies is elaborated as well a number of guidelines for their actual implementation.

The strong evidence about the regional concentration of innovation activities suggests that increasing returns in the production of technological innovation do take place. The high levels of regional concentration in innovation activities, far higher than firm concentration in innovation activities suggest that external increasing returns are at play and that they are stronger than internal ones. The new growth theory literature suggests that increasing returns in the production of knowledge are the result of automatic learning processes which take place in an equilibrium context. The argument we put forward and elaborate in the report is that increasing returns in the production of knowledge are the result of highly contextual conditions where localized technological knowledge assumes a strong collective character. Localized technological knowledge is actually a collective activity only when connectivity between learning innovators is available, opportunitstic behavior is limited for the costs of the leakage of intellectual property rights are countervailed by the advantages of knowledge externalities and efficient communication systems and communication routines are implemented.

The new evidence about the strong regional concentration of innovation activities also suggests that the so-called tragedy of commons need to revisited. The tragedy of commons constitutes a basic tenet of standard analysis. Collective property leads to excessive use of common resources. Overutilization of given resources is the result of failure to assign property rights. The definition of property rights over indivisible resources however can generate other inefficiencies in terms of zoning such as the circumscribing of property rights on watering and the consequent misallocation of water have often shown. The notion of collective knowledge makes it possible to reconsider the tragedies of commons. When collective knowledge matters in fact, the access of each agent has a twin effect: on the one hand it does imply the use of common resources, but on the other hand it helps increasing the common pool.

The notion of collective knowledge helps reconsidering the dynamics of technological districts. Collective knowledge can become a powerful tool for implementing regional and industrial policy when its effects are considered from the view point of the complementarity of the sets of technological innovations which can be generated when using a common pool of collective knowledge, in terms of increasing returns and hence positive-sum-games between learning and co-localized agents which have been able to implement appropriate levels of connectivity.

1. EXECUTIVE SUMMARY

Technological districts can be considered complex institutions characterized by high levels of technological communication systems which imlmplement and favor the ex-ante coordination of innovative labor and the coplementary specialization of firms in distinctive and yet interdependent process of accumulation of localized technological knowledge. The empirical analyses make it possible to identify a variety of communication channels. Each of these communication systems in turn differs widely in terms of size, density and interactivity. Moreover agents may have a differentiated role within each communication system. Agents can be marginal or central, can be well connected or poorly connected. Agents can be poorly connected to strong actors and well connected to weak nodes.

The interaction of the different layers at which communication operate and the quality of each communication system, as well the appreciation of the role of each agent within each communication system provide the final picture which can approximate the actual capability of firms to participate into the general communication process and the chances it has to take advantage of the existing and fragmented pieces of technological knowledge available in the system. The innovative behaviour of firms is deeply affected by the local 'milieu' in that it provides the communication context and hence the intersection of classical agglomeration effects with specific firm effects and the features and characteristics of the distribution of existing technological knowledge, now viewed as an essential intermediary product. The complexity and multilayer dimension of local communication systems provides an important agenda for empirical research. Communication layers in fact complement each other especially within regional clusters where proximity and agglomeration provide an intricated web of complementary interaction mechanisms.

In turn regional clusters can be ordered in terms of the variety and complementarity of communication layers in place: technological districts can now be defined as industrial districts where technological externalities and low communication costs are especially conducive to fostering the rate of introduction of technological changes and add on to the positive effects of agglomeration in terms of pecuniary and technical externalities.

The empirical evidence provides also important inputs to understand the processes by means of which technological districts emerge. Technological districts appear to be the a the result of a variety of alternative paths. Technological districts may emerge from: a) Marshallian industrial districts induced to innovate, as it is the case of the Alcalena district; b) the reorganization of large corporations and their increasing levels of outsourcing, as it is the case of Lisboa and Torino; c) the integration of complementary activities engendered by science parks and the co-localization of research labs of large corporations.

The theoretical analysis and the empirical evidence gathered make it possible to qualify the regional aspects of the production of knowledge and to identify the technological districts. Localized technological knowledge has strong elements of modular indivisibility and local appropriability. Knowledge externalities are much more circumscribed than currently assumed. Actual efforts to assimilate external knowledge and blend it with internal one are necessary: technological communication within well identified contexts plays a key role. Technological communication with low transaction costs in an externality-rich environment is conducive to actual increasing returns in the production of knowledge The technological district is characterized by high levels of technological communication in place. Technological communication among innovative firms makes stronger and accessible the collective character of technological knowledge as an intermediary input into the production of new technological knowledge. When and if technological knowledge acquires strong elements of a collective activity, relevant increasing returns, in the typical form of externalities take place. The technological district is the result of the regional agglomeration of innovative firms.

Location plays a major role in enhancing technological communication for its positive effects on both connectivity and receptivity effects, provided a variety of communication channels are in place. Each of these local communication channels differs widely in terms of effects, because of the role of density and interactivity. Moreover agents may have a differentiated role within each communication system. Agents can be marginal or central, can be well connected or poorly connected. Agents can be poorly connected to strong actors and well connected to weak nodes. The interaction of the different channels at which communication operate and the quality of each communication system, as well the appreciation of the role of each agent within each communication system provide the final picture which can approximate the actual capability of firms to participate into the general communication process and the chances it has to take advantage of the existing and yet fragmented pieces of technological knowledge available in the system.

The innovative behaviour of firms is deeply affected by the local 'milieu' in that it provides the communication context and hence the intersection of classical agglomeration effects with specific firm effects and the features and characteristics of the distribution of existing technological knowledge, now viewed as an essential intermediary product. The complexity and multilayer dimension of local communication systems provides an important agenda for empirical research. Communication channels in fact complement each other especially within technological districts where proximity and agglomeration provide an complex web of interaction mechanisms.

In turn regional clusters can be ordered in terms of the variety and complementarity of communication channels in place: technological districts can now be defined as regions where important local technological externalities are available and low communication and transaction costs are especially conducive to fostering the rate of introduction of technological changes and add on to the positive effects of agglomeration in terms of pecuniary and technical externalities.

The notion of technological communication makes it possible to appreciate the role of local and modular technological externalities and yet complement it with the notion of transaction costs in the absorption and communication of external technological knowledge. While the notion of technological externalities is consistent with the Arrovian notion of technological information, a public good with low levels of appropriability and excludability, it misses the key role of the specific costs that the decodification and understanding of available information entail. The traditional approach in fact assumes that technological externalities are global and general: i.e. they do spill freely in the environment, apply to all technological contexts and no provision is made to take into account the relevant costs of search, decodification and assessment of existing technological knowledge dispersed in a myriad of agents and buried in tacit and idiosyncratic procedures. Technological communication differs from technological externalities. Too much emphasis has been put in the innovation systems literature on technological externalities as if external technological knowledge could be acquired freely in the 'atmosphere' without dedicated efforts. In other words it is not sufficient that technological externalities be freely available in the air for effective use and assimilation to take place.

Substantial communication costs are to be accounted for. The notion of technological communication seems far more appropriate to the new theorizing about the quasi-private nature of localized technological knowledge from the allocation viewpoint and the collective nature from the generation viewpoint.

Technological communication consists of a complex mix of spontaneous and yet controlled forms of social interactions. Exchange of information takes place in quasi-markets which complement and assist the actual trade of goods and services. Firms accept some leakage in their proprietary knowledge, provided adequate returns are made available. This is all the easier in positive-sum-games such as increasing returns in the production of knowledge make possible.

The evidence gathered suggests that localisation within technological districts plays a major role in favouring ex-ante coordination among innovating agents. Better information of the research agenda and mutual understanding of the competencies of agents are available within technological districts: this favours the division of innovative labor enhancing the specialization in complementary but dissimilar innovation activities and reduces duplications. Opportunistic behavior is also restrained within technological districts for the long-terms interactions associated with co-localization: co-localization, as a matter of fact, can be thought of a symmetric hostage. As a consequence, better implicit coordination of investment decisions is achieved within technological districts where information about the market conducts and the technological strategies of each agent is easier to gather.

To a large extent intentional co-localization within technological districts and active participation in local communication systems can be thought of as a distinctive form of technological cooperation which can complement and even substitute for more formal technological partnership within footloose technological clubs. The quality of receptivity and connectivty among agents can be influenced by intentional strategies such as the location in close vicinity to other innovators. Location within technological districts moreover is also relevant for other factors than communication as it can help ex-ante cooperation at large to take place favouring the coordination of different agents both with respect to technological strategies and investment decisions.

The enhanced and localized division of interindustrial labor, not only within the manufacturing industries but also and especially between manufacturing and service industries and across service activities, seems extremely relevant for technological communication to take place. In this context the local supply of knowledge intensive business services plays a key role. Here in fact it is clear that vertical integration within manufacturing companies of an array of advanced services reduces the scope for dissemination and recombination of specific technological knowledge that once generated for one single use can be easily applied to a variety of different contexts. This approach makes it possible to appreciate the characteristics of regions in terms of sectoral composition and the related opportunities for technological outsourcing of firms. The distribution and quality of knowledge-intensive business service industries in fact have important effects on the economic system in terms of innovative capacity. An increase in the exchange of tacit knowledge, made possible by the local supply of the services of consultants and advisers, improves connectivity between agents, sharing learning experiences and creating learning opportunities, and thus advances receptivity. Similarly, improved business services, in terms of distribution, capillarity, competence and access, improves the interaction between tacit, localized knowledge and increasingly larger amounts of generic knowledge, and in so doing is conducive to the accelerated introduction of technological and organizational innovations and solutions specifically tailored to a firm's individual needs. An active local supply of knowledge-intensive-business-services can stimulate technological outsourcing and hence the demand for knowledge-intensive-services by small and medium-sized firms in particular. The integration of local academic units in such a market for knowledge-intensive-products seems to have beneficial effects both for Universities and research institutions at large and for firms.

Second and most important, our large empirical evidence shows that urban and especially metropolitan areas provide a far more positive environment for communication to take place and hence more opportunities to foster the rate of technological change. Proximity and spatial density enhance technological communication also informally for the higher chances for repeated interactions among heterogeneous and yet complementary agents. Co-localized firms within metropolitan areas have higher chances to share a common language and hence to save on the costs of codification and decodification of information about technology as well as business conditions

Finally the evidence suggests that the coexistence of large and small firms active in a variety of industries, both within a filiere and across filieres is especially conducive to favor technological communication. Metropolitan areas seem able to provide the mix of variety and complementarity of economic activities, endowment of scientific infrastructure and high quality of communication systems which favor technological communication. This marks a relevant difference with respect to the Marhallian industrial districts and characterize technological districts. The traditional Marshallian district in fact, especially in the Italian literature, is mainly characterized as a regional space with lower levels of population density and low levels of intraregional concentration of plants and firms.

The technological districts can be considered as the result of an evolutive process with respect to the industrial district. The accumulation of technological knowledge becomes central in the technological district as it is the division of labor within the manufacturing industry in the industrial district. Not all industrial districts can become technological districts. The growth of large firms seems to play a key role in such a transformation together with the local and spatially rooted supply of three important institutional factors: knowledge-intensive-business services, universities and financial services.

The distribution and quality of knowledge-intensive business service industries have important effects on the local economic systems in terms of communication and hence innovative capacity. The local supply of the services of consultants and advisers improves connectivity between agents, sharing learning experiences and creating learning opportunities, and thus advances receptivity. An active supply of knowledge-intensive-business-services, in terms of distribution, capillarity, competence and access, can stimulate the technological outsourcing demand by small and medium-sized firms in particular, with in-house R&D. Advanced telecommunication networks, including high speed data communication and high-definition images, play an important role in favouring the local division of innovative labor among research units and learning firms. As a growing evidence confirms, digital communication can complement rather than substitute for person-to-person communication. Technological districts with high-quality communication infrastructure can benefit from the spiralling interactions between digital and vis-à-vis communication.

The quality of local academic infrastructure is an important factor in enhancing the capability of firms to absorb collective knowledge and make a productive use of it for the increased opportunities to take advantage of technological externalities and benefit from the interaction with the academic community. Agglomeration again can favor formal as well as informal university-enterprises interaction and hence successful technological communication.

In the traditional organizational and institutional set-up, Universities were expected to provide global externalities mainly with the publication of the results of their research and the training of post-graduate students, able to read the publications, which would enter the business community. The access to such knowledge externalities however appears viable only when (and if) it is complemented with the actual access to local externalities. This in turn can take place only if and when the academic and the business community have established clear ways of interaction and communication as it is often the case in the US institutional set-up. In this context not only scientific excellence is achieved in many fields and the flow of postgraduate students from Universities to firms is high. The funding of academic research activities by firms outsourcing extramuros basic research activities is a third growing vector of technological communication between Universities and the business community.

Two additional communication tools have emerged: academic entrepreneurship and academic supply of knowledge intensive business services. Universities enter more and more the markets for knowledge intensive business services and provide advanced services especially to local companies with a clear bilateral advantage. Academic researchers are exposed to specific technological problems with beneficial effects on on-going scientific research. Local companies can access a pool of advanced competencies and dedicated infrastructure often characterized by strong indivisibilities and huge unit costs, which are provided at low incremental costs. Co-localization here favours repeated interactions in the market place and their implementation with personal contacts.

Academic entrepreneurship is more and more becoming the fifth major channel of technological communication between Universities and the business community. Universities become incubators of scientific entrepreneurs on many counts. Researchers are professionally solicited to exploit directly new scientific breakthroughs elaborating technological applications: the creation of start-ups is welcomed in the new academic ethic. Secondly, Universities are actively involved in supporting academic start-ups with the provision of infrastructure and space: proximity plays a major role in sustaining academic start-ups. Start-ups are founded in the region nearby as a way to minimize risks. Proximity here is an insurance against failure: exit from University is often delayed and can be resolved only when and if the new venture is successful.

Academic entrepreneurship, extramuros research activities conducted on behalf of firms externalizing scientific activities and academic supply of knowledge-intensive-business-services enhance the local character of knowledge externalities spilling from Universities; while the traditional tools - academic publications and the supply of graduate trainees - had a much lower local content and rather a global reach. The interaction between global and local externalities here becomes crucial in favouring the effective capabilities of technological districts endowed with a strong academic community to sustain high rates of accumulation of technological knowledge. This is rarely the case of the European institutional set-up where as a matter of fact the empirical evidence upon the positive effects of academic externalities is much less strong. In continental Europe however the strong commitment of academics in private consulting however, especially when favored with the part-time practice, seems conducive to a fast dissemination of new technological knowledge. A trade-off between dissemination, favored by private consulting, and generation, implemented with institutional participation, seems to emerge in this context.

Financial services play a major role on many counts. First of all advanced financial services can supply venture-capital. Second, advanced financial services can assist the dynamics of corporate spin-offs and the continual reorganization of corporations. Thirdly and most importantly however, advanced financial services are active factors of interorganizational mobility because of the possibilities for merger and acquisitions they offer and hence the changes in the borders of the firms in terms of external growth via integration and diversification as well as sell-of with increased specialization with major positive effects in terms of technological communication. From a technological communication viewpoint financial markets, especially when dedicated to new innovative firms, can become a major tool to implement the 'mix and match' generation of new technological knowledge. Local accessibility to such financial services in turn become a key factor in sustaining the rates of introduction of technological change.

The empirical evidence provides also important inputs to understand the variety of paths by means of which technological districts emerge. Technological districts can emerge from Marshallian industrial districts induced to innovate, from the reorganization of large corporations and their increasing levels of outsourcing, from the integration of complementary activities engendered by science parks and the co-localization of research labs of large corporations.

The endowment of technological districts in a country can become an important factor to fostering the rate of introduction of technological innovations at the aggregate level and to shape its direction towards techniques, products and processes that are consistent with the localized features of each economic system at large.

The identification of sensitive relations among local economic activities according to their contents in terms of technological complementarity and technological communication routines can become an important ingredient to elaborate regional strategies of specialization to achieve the proper mix necessary to activate the dynamics of collective knowledge and hence benefit from localized increasing returns in the production of knowledge. Local collective institutions can experiment bottom-up integrated microeconomic policies including elements of regional, industrial, innovation and science policy.

2. BACKGROUND AND OBJECTIVES

The background of the paper lies at the merging of the literature on industrial districts and the related rich empirical evidence and regional policy with the new evidence about the regional clustering of innovation activities. The main objective of the undertaking has been the identification of the conditions and circumstances which are likely to characterize a regional context which can be conducive to the clustering of innovation activites.

3. SCIENTIFIC DESCRIPTION OF THE PROJECT RESULTS AND METHODOLOGY

The report is the result of a long and detailed enquiry on European industrial districts characterized by significant levels of innovation activity. The evidence gathered with patient fieldwork has made it possible to elaborate an integrated interpretative framework which has been eventually applied to a smaller number of highly significant technological districts. The first chapter presents the interpretative framework as it results from a twin inductive and deductive process. Selective evidence about 16 cases is provided in the second chapter of the report. Chapter 3 provides an articulated analyses of the statistical evidence and the chapters 4 and 5 extract and develop the relevant policy issues.

3.1. COLLECTIVE KNOWLEDGE: COMMUNICATION AND INNOVATION[1]

Technological knowledge is a collective good in that its generation is the result of a process that combines pieces of information and knowledge that are owned by a variety of parties and cannot be traded as such. With low transaction and communication costs knowledge externalities can fully deploy their effects in terms of increasing returns and positive feed-backs. The conditions and features of such communication processes explain the clustering of innovations in well defined regional spaces. Localization in technological districts featured by multichannel communications systems and implemented with active participation into the web of embedded exchanges of technological knowledge favours the access to external knowledge, now viewed as an essential intermediary input in the generation of technological knowledge, and pushes the introduction of localized technological changes, leading to self-reinforcing mechanisms based upon localized increasing returns.

The clustering of fast rates of introduction of technological changes in well defined regional districts has been the object of a growing attention in recent economic analysis (Jaffe, Trajtenberg and Henderson, 1993; Feldman, 1994; Patel, 1995; Swann, Prevezer and Stout, 1998).

Two traditions of analysis have contributed this field: the transaction and the externality schools respectively. The externality approach stresses the role of increasing returns within circumscribed regional spaces to which firms have access because of the important role of proximity. Externalities stem from imperfect divisibilities among production factors: proximity provides enhanced opportunities for agents to internalize their benefits (Brusco, 1982; Antonelli, 1986; Becattini, 1987). The transaction costs approach on the opposite values the role of proximity in terms of enhanced confidence and trust that make it possible to reduce the costs involved in the definition of a proper price for goods that have been already manufactured (Storper and Harrison, 1991; Harrison, 1992).

Although the two approaches are often mingled in most analyses, it seems important to stress that they refer to radically different analytical frameworks. The externality approach in fact has been elaborated to accommodate increasing returns. On the opposite the transaction cost approach identifies such local systems as 'perfect markets' where no market failure takes place and ex-post co-ordination is perfectly carried on by markets. An effort seems necessary to provide a single integrated framework which actually combines the two approaches and yet is able to appreciate their distinctive features.

Recent developments in the economics of technological knowledge have stressed the demise of the linear model which related unidirectionally scientific progresses to technological advances and the decline of the notion of technological knowledge as a bookshelf of blueprints easily available to everybody (Kline and Rosenberg, 1986). A new understanding has been implemented. In this new approach technological knowledge is distinct and yet biunivocally interactive with scientific knowledge (Metcalfe, 1995). Second and most important, technological knowledge is now viewed as an indivisible and yet fragmented and dispersed stock of structured information. Because of its highly idiosyncratic applications and specific contexts of implementation, technological knowledge is embedded in a great variety of specific

[1]by Cristiano Antonelli

productive and market conditions and partially owned by a wide variety of agents each of which is able to command a limited portion of it (Cohen and Levinthal, 1989). Thirdly, following and elaborating upon Simon's contribution (Simon, 1985; Loasby, 1998) innovative capabilities and broadly the ability to generating new technological knowledge are now viewed to rest upon a specific learning capability which draws from diverse knowledge bases and is able to activate a systemic recombination process.

Specifically, in a framework elaborated at the crossing of the Marshallian and Neo-Schumpeterian traditions, the generation of new technological knowledge is now viewed as a localized process heavily dependent on the multiplicative relationship of: i) internal learning processes which lead to the accumulation of tacit knowledge; ii) internal R&D activities which enable codified knowledge to be gathered; iii) the access to the external tacit knowledge, experience and competence independently owned and implemented by each firm; and iv) the recombination of the stock of existing codified knowledge, external to each firm and yet internal to the economic system. In such a complex mix, each element is indispensable (Antonelli, 1999).

This approach to the economics of technological change and the new emphasis on the key role of existing internal and external knowledge, viewed as an essential intermediary input, makes it possible to reconsider the notion of technological information as a public good.

The public character of technological information emerges in the context of allocation analysis. According to a long standing tradition technological innovation should be considered a public good in that 'one man's consumption does not reduce some other man's contribution' (Samuelson, 1954 and 1955). Following Arrow's seminal contribution, technological information in fact exhibits the classical features of non-excludability and non-rivalry in use and as such is difficult to appropriate. The definition of technological information as a public good is clearly referred to its conditions of distribution and usage, rather than to the conditions of the generation process.

A different picture emerges when attention is focused on the conditions of production of technological knowledge. From this view point technological knowledge exhibits clear features of a collective good. A collective good is found when it production process is shaped by radical indivisibility and hence complementarity of inputs, yet embedded in a variety of idyosincratic contexts of application of learning agents.

The production of technological knowledge is heavily shaped by the characters of both horizontal and vertical indivisibility and systemic cumulability. The generation of new technological knowledge is in fact affected by vertical indivisibility or cumulability in that it is generated mainly using previous technological knowledge; i.e. standing on the shoulders of giants. The generation of new technological knowledge is also characterized by horizontal indivisibility in that each increase, even with a narrow scope, can have relevant effects in terms of complementarity and additionality with other parallel and yet convergent advances made in seemingly unrelated fields and contexts (Stephan, 1996).

Because the generation of technological knowledge is characterized by radical indivisibility, increasing returns can take place.

Major economies of density shape the cost function of innovation activities. In fact the accumulated stock of competence and technological knowledge acquired by each agent exerts strong inter temporal effects so that average costs decline with the repeated use of such superfixed production factors. For the same token much innovation costs, that is the costs of generating additional technological knowledge and extracting relevant technological innovations, can be portrayed as incremental costs which add on to existing long term fixed costs.

Because of inappropriability, horizontal indivisibility and systemic cumulability externalities matter in the production of technological knowledge. Externalities, as it is well known, emerge from imperfect divisibilities of production factors. The useful distinction introduced by Griliches (1992), building upon Scitowsky (1954), between rent technological externalities, i.e. pecuniary externalities for which external knowledge is actually purchased at low(er) prices with significant consumers' surplus, and knowledge externalities for which technological information is available in the atmosphere, seems very useful.

In this context both the stock and the increases of external knowledge become relevant. The generation of each new bit of technological knowledge by each agent requires the access to the (fragmented) pool of existing knowledge. Moreover the generation of new knowledge by each agent benefits from the instantaneous access to the new bits of knowledge generated by each other agent. In another words the perfect access of each agent to: i) the knowledge stored in each other agent and ii) the research and learning activities of each other agent would greatly enhance the productivity of resources invested in the generation of new knowledge.

In this context it is clear that the productivity of each piece of knowledge is greatly enhanced if each innovating agent is ready to put it in a common pool each piece of knowledge which in fact is complementary to a variety of others. More generally the generation of knowledge can provide the archetypal evidence of a network process where the productivity of the resources is larger the larger the number of agents that do take part with clear network externalities effect on the supply side. The productivity of each specific asset is a function of the number of complementary pieces each other agent is ready to contribute the (collective) undertaking.

Technological knowledge however is dispersed among many different agents and institutions as well as the generation of new knowledge takes place at the same time at each agent's premises. Hence the costs of searching, locating and accessing the relevant external knowledge and its effects on the production of new knowledge by each firm play a major role.

Our basic argument can now be put forward: regional clusters of innovative firms emerge where and if actual collective pools of technological knowledge become available and learning innovators are actually ready to socialize their own bits of localized knowledge. When technological knowledge takes relevant collective features, increasing returns in its production are possible.

Technological knowledge is collective when and if it is the result of a collective undertaking in that its generation is the result of a process that combines pieces of information and knowledge that are owned by a variety of parties and cannot be traded as such. From this view point the definition of a collective good such as specifically technological knowledge is referred to the production process of a new good, rather than its allocation. Within this framework the collective nature of technological knowledge stresses the importance of the conditions for accessing the technological knowledge already stored, but dispersed in a myriad of applications and its developments. These conditions become a key factor to improve the rate of technological advance and attract firms which contribute the emergence of technological districts.

Upon this framework the integration of the externality approach and the transaction cost approaches becomes productive in order to explain why and how some economic environments are more conducive to fast rates of introduction of technological change, for a given amount of dedicated resources, than others. Technological change in fact is primarily generated by technological knowledge which in turn is heavily influenced by each agent's conditions to access the indivisible and yet fragmented pool of existing knowledge.

The static and dynamic access however are made difficult by many transaction costs. First of all the public good character of existing technological knowledge and the related well known appropriability problems play here a major role. Agents are reluctant to make the access to their own bits of knowledge easy because it would further reduce their appropriability conditions, especially for competitors and perspective imitators. Second and relatedly the owners of each bit of knowledge are rarely aware of the value of their own portion of knowledge for other users that are not strict competitors and as such perspective imitators. The stronger the appropriability conditions of existing technological knowledge owned by each agent, and the larger the possibility to trade it in the market place without any risks that access is restricted and rationed, the easier the conditions for both the vendor and the customer to meet in the market place and fix a price for it.

This analysis pushes to reconsider the traditional knowledge trade-off: with a strong intellectual property right regime which does not care for the implicit risks of technology-rationing, the owners of technological knowledge, in the absence of a fully articulated market for technological knowledge, may discretionally limit the access to their knowledge and rationate all technological sales with clear costs in terms of duplication and missed output in terms of unexploited increasing returns. On the opposite a property right regime which does not provide any protection is likely to incentive industrial secrecy with evident costs in terms of communication and search costs for perspective users. An intellectual property right regime designed to enforce both appropriability and derivative usage seems, in this context of analysis, necessary. Derivative property rights on the knowledge generated by means of proprietary knowledge on the one hand, or copyright-oriented intellectual property right regimes which reduce the excludability but enforce the remuneration of owners, might become useful solutions. Thurow (1999) has recently aired the growing concern about the need for a change in intellectual property regimes stressing at the same time the need to better enforce appropriability and yet reduce excludability suggesting that different classes of patents could be created. Technological knowledge with strong generic content, with a large scope for wide applicability to many different economic activities could be patented but with the obligation to compulsory licensing. Extensions of existing knowledge with a stronger idiosyncratic content could be patented with high levels of excludability (see also Scherer, 1999).

The access to existing knowledge however is harmed by relevant communication costs. The complementarity to own technological knowledge and own research agenda of each other bit of knowledge and each other research and learning on-going process is a matter of discovery and time-consuming activities. Relevant search, decodification and assessment costs may induce each agent to reproduce internally the necessary knowledge with high opportunity costs in terms of un-exploited increasing returns. Technological knowledge in fact is industry-specific, region-specific and firm-specific; and because of this it is costly to use it elsewhere: respectively in other industries, other regions and other firms (Antonelli, 1999).

The stronger the codified content and the lower are the decodification costs, the larger is the possibility for perspective customers to screen the market place and assess the relevant bits of knowledge which are actually complementary. Clearly when and where each bit of technological knowledge is kept hidden and obscure by the strategic behaviours of owners worried about the low replication costs and high imitation opportunities for third parties and moreover the search, assessment and decodification costs are high because of its large tacit and idiosyncratic content, the access to external knowledge become extremely costly and is substantially barred (Hirschleifer, 1971).

The notion of collective goods is here relevant in that it entails also, and strongly, the case for externalities. In our communication approach, knowledge technological externalities matter as much as rent technological externalities. Three specifications of the current notion of knowledge externalities need to be considered here and the distinctions between local and global, modular and general and symmetric and asymmetric externalities seem relevant.

The distinction between global and local externalities plays a major role. Global knowledge externalities have effect without limitations in distance. The signal is so strong that everybody can hear it and receive the relevant message. Knowledge externalities can spill freely in the atmosphere without any dedicated effort and any limitation in the capability of perspective users to actually receive and assimilate it. Externalities are local when instead the limitations to receiving and assimilating the information spilling in the atmosphere are relevant and entail real communication costs. Distance in regional space can measure the decay of the strength of the signals carrying the externalities and beyond a given ray externalities are worthless. When localized technological knowledge matters, and its idiosyncratic and specific characters are stressed, knowledge externalities tend to be local rather than global and relevant communication costs are to be assessed. Externalities spill within a limited region.

On a similar ground the notion of localized technological knowledge, and the related rich empirical evidence on contextual knowledge, make it possible to introduce the distinction between modular indivisibility as opposed to generalized indivisibility. The Arrovian tradition assumes that knowledge indivisibilities are general so that each element of knowledge belongs to a single body. In the localized knowledge tradition of analysis a plurality of knowledges is identified. Each knowledge relates to each other with strong and weak indivisibilities respectively. Knowledges characterized by strong indivisibilities belong to the same modules. A chain of weak indivisibilities relates each module or cluster of knowledges to each other. The notion of modular indivisibility is important because it leads to appreciate the clusters of technological knowledges and technological innovations which impinge upon a common of knowledges characterized by strong indivisibilities. Consequently knowledge externalities are very important within modules, but less strong across modules. Hence we can introduce the distinction between modular externalities and generic externalities. Knowledge externalities and technological communication among innovators endowed with complementary bits of knowledge, within the same module, matter more than knowledge externalities and technological communication across all innovators in any technological field. Co-localization in the technical space and hence co-specialization of complementary innovators, acting within the same technological module, is more important, in order o achieve increasing returns, than co-localization of weakly related innovators.

The distinction between symmetric and asymmetric externalities is also relevant in this context. The first case clearly applies to two companies working in totally unrelated industries which can share symmetrically the benefits of some technological breakthroughs. The former case instead applies to typical user-producer relations where either one is able to take advantage of the knowledge generated externally. Within technological districts, when and if the dynamics of collective technological knowledge is put in place, the advantages of positive-sum-games, stemming from increasing returns, are evident. Even with asymmetric externalities, less favored parties have an incentive to participate. Second and most important, co-localization becomes quickly a hostage and a source for repeated transactions: opportunistic behaviors and systematic lack of reciprocity would be easily sanctioned with exclusion. Localization and related irreversibilities oblige to consider long-term strategies.

The conditions for symmetric externalities in the communication of technological knowledge are very strong for all parties engaged in technological communication 'share the same code' and hence symmetrically benefit of a radical reduction in the huge decodification and search costs necessary to locate the bits of existing and external knowledge which can be directly relevant to each firm's generation process of new technological knowledge. Technological communication itself is a collective good where each agent and each party is interested in enhancing the communication conditions among all the members of the community.

Technological communication moreover is an interactive process where both parties are actively and purposely involved. The levels of effective technological communication depend upon the resources devoted by each agent to establish technological connections with other firms and academic and scientific institutions in innovation systems and the amount of information that each firm is able to receive and actually assimilate from the innovation system in which it operates.

The institutional context of economic systems in terms of communication conditions plays a major in assessing their innovation capabilities. The access to external tacit and codified knowledge depends on the extent to which effective communication among innovators takes place through the innovation system. In this context the properties of economic systems, conceived as communication networks into which information flows, matter in explaining the capability to generate new technological knowledge (Hayek, 1945; Lamberton, 1971, 1996 and 1997).

Within communication networks, we see in fact that at each point in time, the magnitude and the impact of the effective flow of information which is both emitted and received by each agent can be thought to be the outcome of the interaction between two classes of stochastic events: i) the connectivity probability that the flows of effective communication and the exchange of information take place and ii) the receptivity probability that the results of the research and learning efforts of each firm in the system are effectively assimilated. This methodology moreover makes it possible to reproduce analytically the dynamic laws of a process where the actual transfer of technological information can either take place or decay: stochastically in fact communication can fail (David and Foray, 1994; Krugman, 1996; Antonelli, 1999).

The location of each agent within communication flows becomes extremely important in this context. Communication flows are multilayer in that they take place at different levels and involve many different aspects of economic interactions. Moreover communication flows are complex and structured. At any point in time we can observe at each layer well defined structures of communication flows where some agents are better located than others in that some agents have access to more communication links than others, some agents happen to have access to more effective links than others. Specifically we see that some agents can be more receptive than others for a given level of technological externalities available. And we also see that some agents have access to technological externalities at low communication costs, while other have not such access. From the viewpoint of the specific role of each agent within the communication flow empirical analysis provides important insights in that it makes it possible to understand the dimension of the relevant networks in place, their density and their structure so that each agent can be classified in terms of the number and quality of the links in place.

According to the hypotheses outlined above it is assumed that within technological districts the production of technological knowledge by each firm can be formalized as the result of the interaction of internal research and learning activities, the creative access to external technological knowledge and its actual implementation. The different levels of effective communication among innovators, as measured by the mixed probability of communication processes, are likely to significantly affect the productivity of the total amount of resources devoted by each firm to research and learning activities and hence reduce substantially innovation costs (Nelson, 1987).

In sum, technological districts are specific forms of agglomeration characterized by high levels of innovation activities, induced by good technological communication conditions. Within technological districts increasing returns in the production of technological knowledge can actually take place. The agglomeration of innovators in fact is likely to increase the amount of external knowledge available, as well as the access to both rent and knowledge technological externalities. This in turn affects positively the efficiency of research activities and further pushes the firms in its innovative efforts. All the characters of a self-reinforcing mechanism, based upon positive feed-backs are now in place. Local communication probabilities at time t are likely to affect the behavior of agents not only with respect to the levels of their innovation activities but also to the levels of deliberate action taken to build up connections and receptivity which can enhance the efficiency of the funds invested in research activities. Hence the local communication probability at time t+1 is influenced, but because of its stochastic nature, not determined, by the conduct of the firms and the outcome of their interactions at time t.

This process is especially evident within technological districts such as Turin in Piedmont, Modena and Bologna in central Italy, Toulouse in France, Route 128, Los Angeles and Silicon Valley in the US (Antonelli, 1986; Russo, 1985 and 1996; Dorfman, 1983).

3.2. THE STATISTICAL EVIDENCE ABOUT THE CLUSTERED DYNAMICS[2]

1.Introduction

The major part of the INLOCO project is a collection of detailed case studies looking at the dynamics of SME networking in industrial districts or clusters. Each case focuses on a specific industry in a specific region.

This chapter, on the other hand, takes a much wider and quantitative overview of patterns of company growth, entry and innovation in clusters. Why? Surely such statistical analysis cannot offer the rich detail and relevance of individual case studies? Indeed not, but it does give us an important overall picture of the importance and extent of clustering. It is rather like the difference between a small-scale map of Europe and a detailed plan of one town. The

[2] by Catherine Beaudry, Stefano Breschi, Luis Sanz Menéndez and Peter Swann.

tourist may use a small scale map to choose a general area for a tour, and then a detailed plan for walking the streets or lanes. In the same way, in the INLOCO study we combine this statistical overview with a series of detailed studies of particular clusters in particular regions.

In fact, we believe that the statistical approach can actually give quite a rich - if stylised - summary of the way in which clusters work. In much of this quantitative study, we are able to identify whether company growth rates, entry and innovation are correlated with the strength of the cluster. The results suggest that some useful generalisations may be in order about the economic benefits that flow from clustering, but that there are important differences across broad industrial sectors, across sub-sectors of particular industries, and across countries.

In this statistical research, and important part of the work has been to merge different data sets together. This is never an easy task, and in this study we have encountered some major challenges in this respect. However, we have been able to make enough progress to shed some important ñ if preliminary light ñ on the overall pattern of clustering in Europe. In addition, we need to be clear that the definition of clustering that will be used in this chapter is rather weaker than the definition used elsewhere. We talk of clusters to mean geographical agglomeration of technologically related companies, where there is evidence of improved economic performance stemming from this agglomeration. In some of the case studies, this would be a necessary, but not sufficient condition for ìclusteringî. Many geographers, for example, would say that a real cluster only exists if there is prima face evidence of firm to firm networking, transfer of tacit knowledge through staff turnover, or explicit collaboration. Our macro-statistical approach cannot identify these phenomena, because they do not lend themselves to large-scale quantification. But we argue that improved economic performance associated with agglomeration is, at the very least, suggestive of some richer interaction of this sort ñ though clearly not conclusive.

The remainder of this chapter is organised as follows. Section 2 starts with the work based on company data and regional data. This work focuses on two broad questions. First, do firms in clusters grow faster than average? We explore this by comparing lifetime growth rates of firms in strong clusters with those located elsewhere. Second, do clusters attract a disproportionately high amount of entry? Because the European-wide company databases we have do not have a strong coverage of small (and young) companies, we cannot construct a detailed picture of entry. But if it is reasonable to assert that regions with a recent history of above-average entry have a younger that average age profile of companies, then we can learn much from comparing the age distribution of companies across regions.

Section 3 turns to our third source of data: the EPO database of patenting in four European countries, developed and maintained by CESPRI at Bocconi University, Milan. The first part presents an illustration of the spatial pattern of patenting activity in Italy. This is concerned with two main questions: (1) Do agglomeration (dis)economies within regions account for the uneven incidence of innovation across regions? (2) Does technological diversity within a region encourage innovation by promoting higher levels of knowledge spillovers, as well as multiple and complementary sources of new ideas? The second part summarises work by the Spanish team examining to what degree patent statistics are helpful in mapping spatial patterns of innovative activity in Spain. This component of the report recognises that for some regions the incidence of EPO patenting is so small that it does not give a reliable measure.

Section 4 described the third component of this quantitative research, which merges the company and regional databases used in section 2 with the CESPRI/EPO database used in section 3. The work studies to what extent innovative activity is associated with the strength of the region within which the company is located. A limited dependent variable analysis is performed on patent counts of Italian and British companies to examine the effects of geographical clustering on patenting activity. The research suggests an interesting, if preliminary rule of thumb about the relative importance of company size and cluster size on patenting activity. Large firms are more likely to patent than small firms, but to some extent the small firm can compensate for this patenting disadvantage if it is located in a cluster that is strong in its own sector.

Section 5 makes some further observations about how this macro perspective can interface with the micro-perspective of the INLOCO case studies. The natural step here is to apply the statistical methodology to a case study unit ñ and this is what the Manchester team have done in our three case studies: broadcasting, financial services and aerospace. This allows us to see if the econometric effects identified by statistical analysis correspond to a case study reality.

2. Statistical Work Using Regional and Company Data

This section studies how firm performance is influenced by the strength of the industrial cluster (or industrial district) in which it is located. We present estimates of firm-level growth models for a range of 2-digit industries in seven European countries: Belgium, France, Italy, the Netherlands, Portugal, Spain and the United Kingdom. In these models, employment in the firmís own sector and employment in other sectors is taken as a measure the strength of the cluster. Then, in lieu of a full entry model, the age distribution of firms by region yields some useful insights into the economic health of different regions.

Two approaches to modelling growth of firms can been used, one at the level of the firm, and the other at the level of the cluster. The most successful approach works at the firm level, and identifies whether firms located in strong clusters (with strong industry and/or a strong science base) grow faster than isolated firms. In its simplest form, a model of the lifetime growth of the firm can be estimated using employment as a measure of cluster strength. A lifetime growth model is preferred here to a model of year-to-year growth, because the latter is so volatile, and unpredictable. In the model, the trend growth of the firm is treated as a function of cluster employment - both in the firm's own sector, and in all other sectors. The model also takes account of any potential effects of a strong science base and other regional and sectoral "fixed effects" on the trend rate of growth of a firm. Accordingly, the model estimates a trend rate of growth, but also allowance for the possibility that growth may be influenced by clustering with similar firms, with dissimilar firms, or near the science base.

Four categories of economic and demographic regional variables were identified: firm type, categorising a company amongst its peers; employment, representing the size of the firm; economic data, illustrating cluster economic strength; and regional characteristics, showing general cluster strength. In the lifetime growth model defined above, the second category of variable, the number of firm employees, is taken as the left-hand side variable, while the rest are explanatory variables. The firm type is represented by its age, its status and whether it files consolidated accounts or not. Regional economic strength was measured by employment characteristics of each region within 17 NACE-CLIO industry codes, at NUTS level 2, i.e. own and other sectors employment, research & development employment as well as gross domestic product. The number of patents per region was used as a measure innovation activity. Finally, population, area, number of kilometres of motorways and air travel traffic were also used to explore the effects of some other cluster characteristics on the performance of companies located in the cluster.

For much of the regional data extracted from Eurostat REGIO , the best we can consistently obtain for all seven countries studied is data at NUTS level 2. This is somewhat unsatisfactory, since the cluster is generally smaller than a NUTS 2 area - really more in line with a NUTS 3 area. However, studies such as Glaeser et al (1992) and Jaffe et al (1993) have shown that external effects of the kind that are explored here seem to grow stronger as the regional unit becomes smaller. Any bias introduced here should be to underestimate the strength of clustering effects. Nevertheless, the use of regions as a spatial unit has some administrative sense. In some countries, for example, government policies and incentives towards new industries are to some extent defined at a regional level.

Dun and Bradstreetís OneSource Europa for was used to extract company data. Four categories of firm data were considered in the econometric analysis: firm size (number of employees), sector (4-digit SIC 1972 US codes), region (postcode) and type of company (parent, subsidiary or independent). In each country, the company selection criterion employed by Dun and Bradstreet differs, which further reduces the possibility of country comparisons.

Finally, we have to assume that all spillovers from a company x flow out of its headquarters, except in the case of known subsidiaries, where the spillovers flow out of that companyís trading address. This means that the only other companies to enjoy these spillovers are those that share a location with the headquarters of company x. Companies that share location with a plant belonging to x, but located apart from the headquarters of x enjoy no spillovers. On the face of it this seems like quite a strong assumption. But Howells (1984, 1990) has shown that R&D facilities tend to be located fairly close to corporate headquarters, so if it is the R&D centre that leaks most of the spillovers, then the assumption may in many cases be quite an acceptable one.

Regression results

In four cases (Es, Fr, Pt, UK), own-sector employment has a negative significant effect on firm employment growth, and in four other countries (Be, Fr, It, Nl), other-sectors employment has a positive significant effect. These results contrast with those in Swann et al. (1998) and Baptista and Swann (1999), on the computer industry, which found positive values for the own employment coefficients, and negative for other employment coefficients. But these earlier results refer to a very low level of aggregation in a high technology environment, while the present results refer to highly aggregated sector classifications. In addition, these national averages hide some wide variations between sectors. As mentioned earlier, all four scenarios of positive and negative own-sector and other-sectors employment are possible.

A consistent result across all countries, is the negative coefficient on the area of the region, i.e. firms grow more slowly in larger regions. This is probably a consequence of the definition of regions. Regions covering a relatively wide geographical area are usually sparsely populated, both in inhabitants and firms, and are chosen as such to unify government statistics. More populated areas such as Paris and London are subdivided into smaller regions, to maintain a comparable number of inhabitants. Intuitively, in larger areas, companies are less crowded and positive cluster effects are less likely.

Furthermore, most industry dummy variables are significant indicating that it would be appropriate to estimate regressions by industry. In general, the strong significance of the industry dummy variables reflects the fact that pooling here masks important industry differences in clustering effects. In performing regressions by industry, for each country, we find that in most sectors, positive own-sector employment effects tend to outnumber positive other-sectors employment effects. In only two sectors is the reverse true: transport equipment, services of credit and insurance institutions.

We might have expected the industries that show positive cluster effects for most countries to be high-technology ones, given the widespread belief that clustering is most important in such sectors. But that is not what is found here. The first few industries with the most positive cluster effects are building and construction, agriculture, forestry and fisheries, as well as non-metallic minerals and mineral products. There are fewer surprises, perhaps, with those industries showing the least positive cluster effects such as fuel and power products, and non-market services where clustering seems less important.

In a two-by-two grid of own-sector and other-sectors employment, the same sector may occupy a quite different position for different countries. For example, in such a grid, the industry ìbanking, finance and insuranceî is found in the northwest quadrant (-,+) for France, the northeast quadrant (+,+) for Portugal, the southwest quadrant (-,-) for Italy and the southeast quadrant (+,-) for the UK (significant results only). At the very least, this observation suggests that clustering effects are highly specific to the details of industry structure in each country. We can find, for example, that the same industry in different countries can exhibit very different clustering parameters.

The majority of significant results (half of the country/industry results), however, are found in the southeast quadrant, i.e. where own-sector employment has a positive effect and other-sectors employment has a negative influence. In the northeast quadrant, the percentage of significant results represents slightly less than a third of country/industry results of that quadrant. In addition, all significant results for Spain, Portugal, the Netherlands and the UK show positive own-sector employment effects implying that in those countries or industries, firms grow faster than average if they a located in a cluster that is strong in their own sector. The same also applies to most of the French and Belgian significant results.

3. Entry and the age of firms: Rationale for log-normal distribution

Ideally, we would seek to model entry of new firms per cluster per year as a function of cluster strength. In this study, however, the company databases we have (Dun and Bradstreetís OneSource Europa) are not able to give an adequate year to year picture of entry. We face a problem because such company databases do not cover the newest and smallest firms: in that case a new firm's entry is only visible some years later when it has grown to a significant size. And indeed, even then, the entry will only be visible if the firm survives: if it fails, or is taken over, then its entry will simply not show up. We are aware that these issues must arise in the use of Europa. Europa only covers about 22,000 of British firms whereas the full Dun and Bradstreetís OneSource database for the UK vol.1 and 2 covers about 360,000 firms.

However, we shall argue that an examination of the age distribution of firms in clusters can offer some insight, in lieu of a full study of entry. Those clusters that have a relatively young collection of firms have probably enjoyed a burst of entry in recent years. By contrast, those clusters with a relatively elderly population of firms would not appear to have enjoyed entry on this scale. But the mapping is not straightforward, because of course firms have a high probability of failure in their early years. The model developed by the Manchester team allows us to compare - under different assumptions - the relative size of firm entry, firm survival, and the number of firms showing up in a census.

This model, follows on from work by Dunne et al. (1989) and Evans (1987). It shows what we can learn from measures such as ìnumbers of entrants who survive for s yearsî, where the appropriate cut-off value, s, can be assessed by looking at the empirical age profile of firms. Technically, this limitation of the data is a source of sample selection bias, but we argue that being unable to measure "ephemeral" entry is not altogether a bad thing. Since the overall aim of the study is to evaluate how clusters contribute to long term growth, there is in fact a case for making a virtue out of necessity and excluding ephemeral entrants from the sample, and focusing on the growth and entry behaviour of the successful surviving firms.

Results

For all the countries examined, the year of incorporation of each company was taken from Dun and Bradstreetís OneSource Europa database. This database contains the larger firms in each country, and not the smallest. For each country the age of each firm was calculated and a lognormal distribution fitted for each NUTS level 3 geographical region. The Netherlands has a relatively low firm mean age, but has the highest density of firms in this group. Belgium and the United Kingdom appear to have the highest firm mean age as well as a higher firm density than the other four nations. For France, the database includes the greatest number of companies, and in view of the analysis above, it is not perhaps surprising that France is measured to have a low mean age of firms. But this argument does not apply to the UK, which has the oldest firm mean age of the group. As we do not believe that there should be such a large difference in mean age between France and the UK, this suggests that some sample selection biases arise in making comparisons across different countries within the database.

For each NUTS level 3 region, a lognormal distribution was fitted to the age distribution of firms, and the mean age was computed. From these results, we observe that two of the major metropolis, Rome and Madrid appear to have a low mean age of firms, within a region where the density of firms is high. In Brussels, Paris and Amsterdam, firm mean age is higher, but this is not to say that these regions have a lower level of entry than their neighboursí capitals. In France, the Nord region shows the same pattern of high firm density and low firm age that is found in the Region Parisienne (Greater Paris). But much of the rest of France has a relatively low firm mean age. In Italy, it is interesting to note that some of the most successful regions in the north have a relatively high mean firm age, while the lower income areas in the south have a relatively low firm age. This is an interesting contrast to the picture in the UK.

For most regions of the UK, the average age of companies as computed from the Europa database is somewhat higher than in the rest of Europe. For this reason, we also extracted the 360,000 companies from the full OneSource UK vol. 1 & 2 database. As expected, with this much larger sample of companies, the mean age of the companies in each region drops. In the south of England, many regions have a mean age of firms that is smaller than in most of the rest of the country. This occurs especially along the so-called ìM4 corridorî, where the emergence of successful new firms in high technology fields has been a much-discussed and economically important phenomenon in recent years.

Some of the differences illustrated here may reflect national differences in the selection procedure applied in the Europa database. This makes international comparisons difficult, and we need to keep in mind the sample selection bias mentioned previously. Nevertheless, since there are typically considerable differences in the way that different national databases are assembled, there are considerable attractions in using company data for different countries from the same database.

4. Statistical Analysis using Patent Data

The second strand of research explores regional patterns in patenting activity. Here the unit of analysis is the region or province, rather than the individual company. However, the data used here can (with some considerable difficulty) be brought together with the data described in the last section. Section 4 will summarise the INLOCO work directed at pooling all three data types - regional, company and patent.

The section summarises two studies. The first, by Breschi, examines the clustering of patenting in Italy, drawing on EPO (European Patent Office) data. The second, by Sanz-MenÈndez, examines the equivalent pattern in Spain, but this study reveals some of the difficulties in using the EPO data for this purpose. In some regions of Spain, the total numbers of patent applications to EPO are very small, and hence it is difficult to draw reliable picture. Nevertheless some important trends emerge.

Geographical Clustering of Patenting in Italy

This part of the quantitative project focuses on the localisation and geographical clustering of innovative activities in Italy. To date, most empirical research on this subject has focused upon the United States. The reason for this is the lack of suitable regional data both on innovative and economic activities for Europe. Many of these data are still collected at a broad spatial (NUTS 2) and broad sectoral (NACE 2-digit) level of aggregation. This is not ideal from the perspective of empirical researchers. Knowledge spillovers and external economies are strongest in a relatively small geographical area, and hence it is preferable that data should be collected at the "county" level (NUTS 3). Moreover, broadly defined industrial sectors such as the NACE 2-digit industries contain sub-sectors that differ strongly from each other, both in terms of technological regimes (opportunity, appropriability and knowledge base) and structural features (economies of scale, barriers to entry and skills of workforce).

This work represents an important advance because, in the case of Italy, Breschi was able to assemble consistent data at the NUTS 3 level (provinces or counties) and NACE 3-digit industry. Breschi's preliminary investigations for other European countries encountered some quite serious difficulties in finding and collecting comparable data.

The aim of the paper was to attempt a test of two broad hypotheses:

1) Do agglomeration (dis)economies within regions (that is, without taking into account the spatial interaction with contiguous regions) account for the uneven incidence of innovation across regions? Or, in other words, do those regions enjoying greater agglomeration economies and knowledge spillovers and lower congestion costs also tend to produce a higher number of innovations?

2) Does technological diversity within a region and other aspects of diversification within a region encourage innovation by promoting higher levels of knowledge spillovers, as well as multiple and complementary sources of new ideas?

This paper makes use of several sources of data. The most important source was the EPO-CESPRI database. The data set contains all patent applications to EPO (European Patent Office) from 1978 onward, by firms and institutions of all countries seeking protection for their innovations in any of the 18 countries adhering to the Munich Convention, which established EPO. For each patent applicant the data set also identifies its spatial localisation as given by the address contained in the patent document. Patents have been classified according to a technology-oriented classification that distinguishes 5 technology areas and 30 technology sub-fields based on the International Patent Classification (IPC). This classification has been elaborated jointly by FhG-ISI, the French Patent Office (INPI) and the Observatoire de Sciences et des Techniques (OST).

Patent applications have been processed at the regional level taking NUTS 3 as the spatial unit. This spatial partition corresponds to the 95 administrative provinces in Italy. Breschi assembled data on the number of patents applied for in each province during the time period from 1987 to 1994, and by technological class. These measures are used as a measure of innovative strength. Of course, the reader will be aware that while patents are useful; measure of innovation they are also an imperfect measure (see Griliches, 1991). In addition, patent applications are a very good indicator of firmsí and regionsí technological competencies. The fact that firms located in a certain region have applied for patents in a given technological field means that such firms are at, or close to, the technological frontier and have advanced technological competencies in that field.

However, a word of caution is necessary about using the applicantís address as listed on the patent application in order to plot the geographic location of the underlying innovative activity. This approach tends to overestimate the actual degree of spatial concentration of innovative activities, because company headquarters often choose to patent innovations developed by establishments located in other regions. Arguably, however, this problem is only of particular concern in those technological fields (notably, chemical) in which multi-plant firms are prevalent. Patent data have been also used to measure the knowledge proximity between different technological fields. Taking all patent applications to the EPO, Breschi et al. (1998) have built a matrix of knowledge proximity across the 30 technological classes, by considering the frequency of co-occurrences of technological classes in primary and secondary classification codes. Such a matrix can then be used to identify clusters of related technologies. Other data used in the study included R&D data, other innovation data from the Community Innovation Survey project, employment data and infrastructure data.

An exploratory analysis of these data suggested the following conclusions:

1) Innovative and manufacturing activities are more spatially concentrated than population. At the same time, innovations are considerably more spatially concentrated than production.

2) There are large differences across sectors in the degree of concentration of innovation and production. Concentration is relatively low in most mechanical engineering and industrial equipment sectors and it is relatively high in most electrical-electronic and chemicals-drugs sectors.

3) There are large differences across sectors also in the spatial patterns of innovative and manufacturing activities. While there is evidence of positive and statistically significant spatial autocorrelation in several mechanical sectors, innovative and productive activities in most chemicals and electrical-electronic sectors are concentrated in few technological ìpolesî that

are surrounded by non-innovative provinces. In general, production displays greater spatial autocorrelation than innovation.

Breschi then estimates a regression model of patenting to test the two hypotheses described above. In this model, the dependent variable is the number of patents attributed to a specific industry in a particular NUTS3 province in the period 1987-1994. Two explanatory variables were used to measure agglomeration economies. The first is the number of employees in the same industry within the province and the number of employees in other manufacturing sectors within the province. A further variable is the number of business telephone subscribers, included as a measure of the strength of information and communication flows within a province. In addition, two measures of knowledge spillovers are included in the model: total R&D expenditures and total investment in innovative capital goods. The model uses measures of the diversity of patenting in a region to allow for the effects of diversity in the knowledge base on innovative activity. Finally, the model also makes allowances for differing congestion costs and regional value added.

The regression results provide support to the hypothesis that strong agglomeration economies and localised knowledge spillovers have a positive impact on the innovative performance of provinces. Innovative performance is also positively associated with a wide and diversified base of local technological competencies, whereas congestion costs have a negative impact on the number of patented innovations. Finally, higher investment in innovative capital goods is associated with a lower rate of innovation, perhaps because such capital investment is a substitute for more formalised innovative activity.

Geographical Clustering of Patenting in Spain

Luis Sanz MenÈndez[3] has analysed the distribution of patenting activity in Spain by technological class and by region. (the report is reproduced, in Spanish, in Report 2.2 of Workpackage 2, Beaudry et al, 1998). The results show some of the problems with the patent count as a measure of innovation in some industries. In particular, the patent counts in some regions are quite small. Nevertheless, this analysis finds a significant growth in the number of regions with patenting activity between the late nineteen-seventies and the mid-nineteen-nineties.

In the 1990s in Spain, and in other industrialised countries in general, there has been an increase in the number of patent applications, while the resources dedicated to R&D have not grown. While this general increase in patenting is in many cases accompanied by significant technological specialisation both in countries and regions, this latter feature does not seem to be present in the Spanish regions. The paper shows how these observations are important for both national and regional policies towards innovation and technology.

Using different databases, the analysis concentrates on two particular issues. First, the paper estimates the degree of concentration of the technological capacities of Spanish regions. Second, it describes the profiles of sectoral specialisation into technological activities, noting that each profile is an indicator of the technological competencies of individuals, organisations and local enterprises in each of the Spanish regions. This work uses information on European

[3]With the co-operation of Esther Arias, Oficina Espanola de Patentes y Marcas. A summary has been published as Luis Sanz-MenÈndez and Esther Arias, Concentracion y Especializaciòn regional de las capacidades tecnològicas: Un analisis a través de las patentes europeas, EconomÌa Industrial n? 323, 1998, V. , pp. 1-18.

patents to provide additional information regarding the technological capacities at a regional scale.

The analysis shows a clear tendency towards an increase in the European patents from Spanish inventors, both in absolute terms, and relative to the total number of European patents. In the mid-1990s, more than 400 annual patents were obtained in Spain, representing 0.7†% of the total of applications. However, for comparison, Spanish scientists account for more than 2% of all international scientific publications.

An analysis of the types of patent applicants noted a negative relationship between the proportion of individual applicants and economic growth. Indeed, of all Spanish applications for European patents considered here, almostmore than 30†% were from individuals. We have also found evidence of extensive collaboration, both for the invention and the rights. Almost 17†% of patents applications are filed by organisations,more than one organisation, while 41†% possess more than one inventor. This tendency towards collaboration, in invention and application, increases with time and is much stronger in high-technology classes such as biotechnology and chemicals.

Spanish technological capacity, measured from patents, shows a high spatial concentration, independent of the indices used in the measurements. The two most important Spanish regions, Cataluna, Catalonia and Madrid, possess more thanalmost 65†% of all Spanish patents. On the other hand, there is a trend towards a reduced concentration, although the majority of Spanish regions possess very limited technological capabilities. Only Catalun„Catalonia and Madrid present a significant variety of technological capabilities in all technological classes. The rest of the regions show much smaller indices of variety.

In general, the indices show a decline in the degree of specialisation in the Spanish regions, which correlates with other trends industrial specialisation, but this seems to be distinct from the rest of Europe. We observe specialisation in some regions around the following technological clusters: electronic, telecommunication and audio-visual sectors in Madrid; chemicals in Catalun„; machine tools in PaÏs Vasco;Vasc Country; and agricultural technologies in Andalucia and Greater Valencia.

By calculating concentration indices for technological capabilities, Sanz MenÈndez shows that this index is higher for Spain than for other European countries. That is to say, regional technical competencies are more unequally distributed in Spain than in neighbouring countries. The same result is obtained from traditional research and development indicators, which again show greater inequalities in technological capabilities (Sanz MenÈndez and Garcia, 1991).

Finally, this study emphasises that the relationship between patenting and measures related only to research and development is not an especially close one. A closer relationship is observed between the regional distribution of patents and the regional distribution of spending on innovation.

5. Statistical Analysis Merging Regional, Company and Patent data

Perhaps the most challenging task of all in our statistical analysis is to merge the data for study 2 with that for study 3, in order to analyse patenting in clusters at the company level. Part of the difficulty was that we found at first sight a surprisingly small intersection between the two sets of companies. In part this stemmed from non-standard treatment of company names in the different databases.

This section studies how a firmís innovative performance is influenced by the strength of the industrial cluster (or industrial district) in which it is located. A limited dependent variable analysis is performed on patent counts of Italian and British companies to examine the geographical clustering of firms. In these models, employment in the firmís own sector and employment in other sectors is taken as a measure the strength of the cluster.

This study by Beaudry and Breschi (1999) uses patent counts as a measure of innovation. The basic model is a Poisson or Negative Binomial model (inspired by Hausman et al., 1984), and has the following form. The number of patents for a given company over a number of years is taken to be a function of: the size of the company; the strength of the cluster in which it is located (measured, as in previous sections, by own-sector and other-sector employment); and a function of sectoral and regional fixed effects.

In the light of earlier findings, it was expected that the effects of the size of the firm and of own-sector employment on patenting activity should both be positive and significant, with the former more important than the latter. The coefficient on other-sector employment could in principle be positive or negative. It would be negative if those firms from a particular sector which are located in clusters that are strong in other sectors are less likely to patent. Conversely, this coefficient could be also positive if there are complementarities and spillovers across sectors.

Two European countries were chosen for this statistical analysis: Italy and the UK. They were chosen mainly because of the relative ease of access to the data for researchers located in these two countries. Three different sources of information have been used: company data, regional employment data, and patent data. These three sources of data are examined in details below.

Dun and Bradstreetís OneSource UK vol. 1 & 2 was used to extract company data for the UK, with the same four categories of company information as for the growth model. The Italian company data were extracted from the Bureau Van Dijkís AIDA database. The same economic information as for the UK companies was extracted, with the exception of company type (not available on AIDA).

Once again, employment data were used as a measure of regional economic strength, but from a different source this time. The UK and Italian Census of Employment of 1991 provide these data, for each NUTS 3 region. For the UK the data are available at the 4-digit UK SIC level (1980 revision), while for Italy, they are available at the 3-digit NACE (revision 1) level. However, for the present analysis, the more aggregated 2-digit level version was chosen for both countries. In addition to the firm, employment and regional variables utilised in the growth study, a Herfindahl index was calculated to measure the employment diversity of each region.

Finally, the third source of information used in the patent data. As in section 3, this comes from the EPO-CESPRI database (documented at CESPRI, Bocconi University, Milan). The database contains all patent applications to the European Patent Office (EPO) from1978 (the year of foundation of EPO) up to 1998. The database contains data related to firms from six countries: US, Japan, Germany, France, Italy and the UK. The processing of UK patent data up to 1998 was not completed in time for this study and the data stops in 1994 for this country. For each patenting company, the EPO-CESPRI database provides the following information: name, address, number of patent applications, year of application, technological class of patent applications. Patent data have been aggregated into 30 technological classes, following the classification table of International Patent Classification codes elaborated by FhG-ISI (Karlsruhe). It is worth noting that the 30 technological classes do not correspond directly to any UK SIC or NACE codes. For this reason, the authors elected to add up all patents of each company into a single count, and as a first approximation to ignore the separation into technological classes, and the possible correspondence between technological classes and industrial codes. In addition to the total number of patents per firm, their study included as explanatory variables the extent to which each cluster has a diversified technological base (Herfindahl index of patents by cluster), and the patenting capacity of the region (total stock of patents for each cluster).

Apart from the problems specific to each database used, another major source of difficulties was the merger of three databases into a single one. First of all, the researchers had to match manually the EPO-CESPRI database containing the names of patenting companies with the business databases OneSource UK and AIDA, containing economic information on companies. The matching ratio of companies included in the EPO-CESPRI database to the company databases is roughly 40†% for the UK and 60†% for Italy, which is not entirely satisfactory. As a consequence, in the UK, 95.4†% of the manufacturing firms included in this database appear not to patent, while this figure decreases to 93.4†% in Italy. The number of patenting firms in the final sample is, respectively, 1091 for the UK and 2510 for Italy. In terms of patents, this corresponds to 7905 patent applications for the UK and 4905 for Italy. As already explained above, the coverage of the final sample is not entirely satisfactory, but was sufficient for the purpose of the analysis.

Concerning the regional distribution of patenting firms, we observe that in the UK, a greater number of patenting firms is located in the south-east of the country, with other patenting clusters located in Lancashire, West Yorkshire and West Midlands. In Italy, patenting companies cluster around a Y-shaped area going from Milan, to Bologna and Vicenza. More than 21†% of all patenting companies (529) are located in Milan. In contrast, in the UK, the Greater London only represents 6.9†% of all UK patenting firms, implying a less skewed distribution of patents towards important urban centres. The share of patenting firms located in the first four largest counties is slightly above 36†%. This figure increases when considering the spatial distribution of patents instead of patenting firms. A third agglomeration of patenting companies can be also found in the Turin region, which is however not surrounded by other equally innovative areas. The south of Italy presents instead very low levels of innovative activities.

Results

As expected, the effects of own-sector employment and firm employment on patent performance are both positive and significant with the latter much more important than the former. Moreover, from the negative and significant coefficient on other-sectors employment, we can deduce, at least for the UK, that firms located in clusters that are strong in other industries tend to introduce a lower number of patents than if the region was strong in their own sector. An interesting phenomenon, however, occurs when introducing in the regression the accumulated stock of patents of the cluster. Indeed, the negative effect of other employment is amplified, implying that the congestion effects are stronger than was previously thought. An important factor is therefore to locate with other firms that patent, and the more they patent the better (as shown by the positive coefficient on the stock of patents). In addition, if a firm patented before, it is more likely to patent again, hence the positive coefficient on that dummy variable.

In the case of the UK the effect of other-sector employment is negative even before the introduction of the stock of patents and the negative effect is amplified by the addition of this variable. Surprisingly, however, in the case of Italy, no congestion effects arising from the presence of other industries are apparent until the stock of patents is introduced into the regression. Moreover, the coefficient on other-sectors employment is not statistically significant when introducing sectoral dummy variables into the regression. Italy therefore shows milder congestion effects compared with the UK.

A noteworthy difference between the UK and Italy concerns the effects of cluster technological and industrial diversity on firmsí innovative performance across 30 technological fields in the period 1978-87. The negative coefficient of the patent Herfindahl index for Italy implies that a cluster with a wider and more diversified technological base encourages innovation by firms. However, there is no such evidence in the case of the UK, as the coefficient on this variable changes sign with the introduction of the stock of patents into the regression. This result seems to suggest that in the UK a more focused and specialised technological base is favourable to firmsí innovative activities. Moreover, it is interesting to note that the same result applies to the Herfindahl index of employment, which provides a measure of the industrial diversity of each cluster.

Other important differences between the results for the two countries considered here relate to the sectoral fixed effects. In the case of the UK, only chemicals, motor vehicles and instrument engineering have strong coefficients. In the case of Italy, a positive and statistically significant coefficient can be observed for a larger number of sectors, amongst which chemical industry, plastic, mechanical engineering, electrical engineering, instruments and telecommunication equipment. These different patterns and the statistical significance of sectoral fixed effects suggest that it may be helpful to estimate separate regressions for each sector, and Beaudry and Breschi (1999) report these sector-specific results.

6. The macro-micro interface

The econometric and statistical analysis presented here is intended to complement the case studies carried out by members of the INLOCO team. While such econometric analysis cannot illuminate the details of the process by which companies benefit from location in clusters, it can give an overall view of the implications of clustering for average company performance. Moreover, while the case studies inevitably have to be selective in terms of the sectors and regions that they cover, this macro analysis attempts an overview for all sectors in many regions.

An important challenge for research in this area is to explore what we can learn from the combination of macro-statistical and econometric studies with micro case studies. This interface is not easy to develop, partly because most researchers specialise in one domain or the other, and few researchers are fluent in translating the implications of one type of work for the other.

Our own approach to this has been to develop an intermediate step between macro-quantitative studies and micro-qualitative case studies. The Manchester case studies are quantitative, applying many of the methodologies described here, but we were able to invest much more time in data collection, and in improving the quality of the data, so that the end results of each study are much richer. Moreover, we can start to explore how the quantitative case study findings resonate with qualitative case studies.

Our three quantitative case studies on aerospace, financial services and broadcasting in the UK (Beaudry et al, 1999b; Beaudry, 1999; Cook et al, 1999; Pandit et al, 1999) are summarised along with the other case studies in the chapter on Workpackage 3 later in this report. Perhaps the most interesting observation is that they are able to distinguish between the strength of clustering effects in the "core" parts of an industry and in peripheral parts. Thus in aerospace, for example, clustering effects are strongest in electrical and mechanical engineering companies, and weaker in parts manufacture. This resonates strongly with our qualitative understanding of the industry. Similar conclusions are found in the other two cases.

7. Conclusion

A brief summary will be useful. Section 2 found further evidence for a pattern that was evident in earlier econometric studies. When we examined the growth of firms located in clusters the most common pattern seems to be that firms co-located with a strong cluster from the same industry tend to grow faster than average. On the other hand, those firms co-located with a strong cluster from other industries tend to grow less fast than average. This is not the pattern in all industries and in all countries. Nevertheless, a majority of own-sector clustering effects are positive and a majority of other-sector clustering effects are negative.

Earlier studies of computing and biotechnology also found that clusters tended to attract a disproportionately high number of new entrants. It has not been possible to study this for all sectors in all seven countries, because the company database used (Europa) does not have wide enough coverage of small firms. Instead, we have tried to draw some inferences about the extent of entry in different clusters from the age distribution of surviving firms in that cluster. Our work developed a model of entry and solves it to show how ñ under certain assumptions ñ a sustained rate of entry, above the average, will show up in a younger than average age distribution of firms. In the UK, for example, we see that some of the most vibrant regions 'along the M4 corridor, from London to Bristol' have a relatively young population. In contrast, some of the older industrial regions with mature industries have a relatively old population. In Italy, in the same way, regions with mature industries in decline show the oldest age distribution. By contrast, the regions with the youngest age distribution are often the more sparsely populated regions. The most successful regions tend to be those with an intermediate age distribution.

As part of our case study work (see Workpackage 3), we were able to carry out an econometric analysis of entry in particular case study sectors in the UK. This is possible because the quality of data we have for the UK is superior.

Section 3 describes Breschi's work examining clustering in innovation activities ñ drawing on the EPO/CESPRI patent database. It shows that patenting is more spatially concentrated than production, but there are important differences across sectors. In the mechanical engineering, industrial equipment and instrument sectors, innovative activities tend to cluster around local systems of contiguous provinces, while in the chemical and electronic sectors, innovative activities tend to cluster around a few metropolitan provinces, which are surrounded by non-innovating provinces. Section 3 examines a Poisson regression analysis of patenting. This finds that localised knowledge spillovers have a positive impact on the innovative performance of provinces. Provinces with a wide and diversified base of local technological competencies enjoy greater innovative performance than others, but there is also some evidence of congestion costs impeding innovation.

Section 3 also summarised work Sanz MenÈndez on the distribution of patenting activity in Spain by technological class and by region. The results show some of the problems with the patent count as a measure of innovation in some industries. In particular, the patent counts in some regions are quite small. Nevertheless, this analysis finds a significant growth in the number of regions with patenting activity between the late nineteen-seventies and the mid-nineteen-nineties.

Section 4 summarises the work done to merge the company and regional data used in section 2 with the EPO/CESPRI database used in section 3. This was not an easy task, but the attraction of doing this was that it allowed us carry out one of the first analyses of patenting at the company level where the explanatory variables are both company specific and region specific. The aim of the work summarised there was to explore whether firms in clusters are more innovative than average. The results suggest that clusters can have a positive or a negative effect on the innovative performance of firms, and the effects depend on whether the firm is co-located with others from the same sector, or with others from different sectors. In general, in this analysis, the influence of own-sector employment was positive and that of other-sectors employment was negative. However, this effect was much stronger for the UK, than for Italy. With the introduction of other explanatory variables, notably of the total stock of patents in each cluster, the effect of other-sectors employment, and to some degree that of own-sector employment was amplified for the UK. This result implies that with the omission of a relevant variable (stock of patents), the congestion effects generated by other sectors employment are underestimated. On the other hand, in the case of Italy, there is less evidence of any congestion effect generated by other-sectors employment. The differences between the UK and Italy are also related to the impact of industrial and technological diversity within clusters on firmsí innovative performance. In the case of Italy, we found that a wider and more diversified industrial and technological base tend to encourage firmsí innovative activities, whereas the opposite seems to hold for the UK.

3.3. A SYNTHESIS OF THE CASE-STUDY EVIDENCE[4]

A systematic field work has been conducted to qualify and verify the hypotheses so far elaborated. A number of regional clusters of innovative activities have been identified and direct empirical analyses to assess the key factors in such regional concentration of innovative activity have been conducted. The fieldwork has been primarily directed to identify the causes of such agglomeration of innovation activities assuming that agglomeration per se is not sufficient for innovation to take place. Technological communication has been identified as the key factor in this context and subsequently the different layers of technological communication have been specified. Technological communication in fact takes place at a variety of levels. Important scope for empirical analysis emerges when the different forms of interactions of firms in the different market places are analyzed from the view point of their implications for communication. This analysis is especially relevant when it can takes into account the variety of channels by means of which technological communication can take place within technological districts as well as the variety of positions within each channel of each agent.

[4]by Cristiano Antonelli

A tentative review of the rich and still growing empirical literature makes it possible to list the most relevant communication channels.

1) Labor markets conditions play a major role. Labor markets provide important opportunities for technological communication to take place. Interfirm mobility greatly enhances the dissemination of information. As a matter of fact external labor mobility is a basic factor in the recombination of existing information and in the regeneration of a common information pool within an economic system. Intrafirm labor mobility perform at the company level similar role although within a narrower scope of action. Hence we can expect that the larger interfirm labor mobility and the larger the rates of technological communication. Economic systems where seniority within companies plays a major role can suffer from a reduced level of technological communication. Even worst can be the case of an economic system with reduced interfirm and intrafirm labor mobility. It is clear in fact that if a too fast labor mobility can reduce the scope for learning processes to take place, a rigid allocation of personnel to limited tasks within the same company can impede the dissemination and recombination of all technological information (Brusco, 1992; Edquist, 1997; Salais and Storper, 1992; Clarysse, Debackere and Van Dierdonck, 1995).

The case study on financial services in the City of London provides important insights on this point[5]. The term financial services is broadly interpreted to include banking, insurance, building societies, stockbroking and investment services. All of these services involve a process of financial intermediation whereby the financial surpluses or savings of certain groups in the economy are collected and redistributed to other groups that demand them. In general, the industry has grown rapidly in the recent past. It accounted for approximately 6% of total UK employment in 1971 rising to 11.8% in 1986 but falling back to 9.9% in 1996 (OECD figures). In most countries financial services cluster together. There are a number of reasons for this. On the supply side, large and complex financial services firms need access to large pools of specialised labour. Thus we observe that merchant and investment banks are almost exclusively based in financial centres such as Greater London, New York and Frankfurt. This point is reinforced by the fact that these skills are in large part acquired by shared experience. For example, knowledge of how to trade Eurobonds is usually gained under the supervision of a senior Eurobond dealer. Conversely, smaller scale, less complex financial services companies such as building society branches and independent insurers which do not rely on large quantities of highly specialised labour tend to be located outside major financial centres. A second supply related explanation for clustering arises from the reliance of financial services firms on supporting services (accounting, actuarial, legal, computing etc.) and again these are most prevalent in major financial centres. A third factor relates to the benefits of trading close to where liquidity is and so it is common to observe financial services companies located in close proximity to national and regional stock exchanges. Demand side benefits include firstly enhanced reputation by locating in recognised financial districts and secondly lower levels of information asymmetry between financial services firms and customers.

Also the case study on broadcasting services in Britain documents the important role of labor markets[6]. The broadcasting industry is comparatively young, with large scale broadcasting, and certainly commercial broadcasting, being an essentially post-war phenomenon in the UK. What is more, the broadcasting industry has been subject to a major shock in the form of extensive deregulation in the 1990s. This has led to rapid entry into the industry and a sea

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[5]by Naresh Pandit, Gary Cook and Peter Swann.

[6]by Gary Cook, Naresh Pandit and Peter Swann.

change in the commercial possibilities within the industry. Labour market pooling effects are important in a number of ways. Above all in the acting profession engagements are likely to be of short duration and from the programme maker's perspective a pool of ready talent is likely to be a distinct advantage. However, it is in the nature of the acting profession that labour is more mobile than in many occupations, so labour market pooling is unlikely to be the whole story. It is plausible that search costs on both sides of the market may be important. Similar considerations are likely to be true for specialist production services, although market pooling effects are likely to be more important since they are less mobile, often having to work with specialised capital which is not easily transportable. Programme production, including post-production, requires a wide variety of different human and physical resources to be combined, typically under tight time constraints. In bringing together these resources in a successful collaboration personal reputations and relationships of trust are highly important and word-of-mouth recommendation is an essential mechanism by which the sub-contracting system works. As independent production grows and more sub-contracting has taken place, this clustering advantage has assumed greater importance.

2) Intermediary markets play a major role in enhancing technological communication. The role of both upstream and down-stream user-producer relations has been greatly appreciated by much economic analysis. It seems clear that an economic system with an articulated industrial structure with many intermediary markets where a variety of firms interact for the provision and purchase of specific intermediary inputs can support technological communication much better that economic systems where vertically integrated firms control the full 'filiere. Proximity and co-localization within local systems favor both the intrasectoral and intersectoral dissemination of technological knowledge both vertically and horizontally. According to a large literature to intersectoral externalities or 'Jacobs externalities' are especially relevant when technological change is relevant. In this tradition of analysis Jacobs externalities contrast the so-called MAR (Marshall-Arrow-Romer) intrasectoral externalities which characterize industrial districts (See Becattini, 1979, 1987, 1989; Brusco, 1992). Our evidence suggests that intersectoral communication are especially relevant within technological modules and when general purpose technologies are at play: agents are much less reluctant to share their knowledge to firms active in other markets. Relevant barriers to communication however arise from the difference of codes and the idiosyncratic character of the information available. New technological knowledge generated in one industry however has often important scope for direct applications in other industries either along common functions or along production filiere even beyond user-producer interactions. As far as intersectoral dissemination is concerned, communication can be thought of a the outcome of a cooperative attitude of agents who can share new technological knowledge with little fear of harming approprability conditions for the difference of markets and customers. The reverse is true for intrasectoral communication: the risks for opportunistic behavior are higher as well as the homogeneity of disciplinary languages and codes. Technological communication here can easily become a factor of imitation. While collective innovation is harmed by appropriability concerns, the diffusion of both product and process innovations is very fast. High levels of intrasectoral division of labor however can solve the tension between dissemination and appropriation: the specialization of firms in a variety of complementary activities within filieres is often the result of MAR externalities which evolve into Jacobs ones (Lundvall, 1985; Russo, 1986;Von Hippel, 1988; Langlois, 1992; Robertson and Langlois, 1995, Saxenian, 1994).

The evidence provided by the case study on the Alcanena tanning district in Portugal confirms the important role of vertical relations within a filiere[7]. The Portuguese tanning is a small

[7]by Joao Ferrao et alii

industry with respect to the Portuguese economy as a whole. With a turnover of some 300 million Euros and directly employing some 4,500 workers, it contributes approximately 1% to GDP. Nevertheless it is a strategically important activity: it supplies the basic raw material for the footwear industry, which is an important export sector in Portugal. Several recent major structural changes have affected the development of the tanning industry in Portugal. The growth phase, since the mid-70s till the end of the 80s, was the result of changes in demand brought about by increased footwear exports. This implied profound changes: tanning factories had to move from fairly simple product lines to very small runs of highly diversified products in terms of type and colour, involving major changes to productive capacity and production processes. At the end of the growth period, brought about by increasing international competition and environmental issues, the industry redefined its product and market strategy in a now increasingly global context. These developments in the Portuguese tanning industry led to progressive concentration in geographical terms, so that during the 1980s Alcanena, a small town about 100 km north of Lisbon, became the industry's main production centre (approximately 217 firms). This area is an example of the evolution of a traditional Marshallian industrial district into a technological district. The main ingredients here are the local technical culture built up over a long period of time, the role of informal socialisation mechanisms and strong specialisation in production. Within this local production system businessmen and companies are very close to each other in social, organisational and physical terms. With progressive globalisation, and the inevitable increase in international competition, this production centre has faced much greater challenges to its competitiveness during the 1990s. Its ability to hold out depends, in large measure, on the way in which the local production system, by means of its cultural characteristics and its institutions, produces, absorbs and disseminates the practices most suited to responding to this situation. The industry's growth phase in the 70s and 80s was characterised by the overriding importance of the surrounding local milieu in the acquisition of technological knowledge by firms through the mechanisms of socialisation. This period was marked by the rapid spread of new products and processes. The circulation and absorption of external knowledge encompassed most of the actors in the system more or less all at the same time. There were practically no barriers to imitation, and those who made pioneering changes derived little advantage therefrom. Even major investment was not a significant impediment, because there was a prospect of a rapid return and basically what was at issue was to incorporate knowledge and norms which were relatively standardised at a global level. The dynamic growth which companies went through at this time allowed the combination of external and internal knowledge to retain a strong element of tacit knowledge. Rigorous compliance with standards and specifications was sacrificed in the interests of producing the goods more quickly. In the same market segment, the stimuli deriving from this situation were transmitted to all companies in the sector which were attempting to develop their internal knowledge by absorbing available local knowledge, either through the local suppliers of chemical products or through local social and labour market networks which allowed for the transfer of knowledge between firms. The specific combination of knowledge in each company derived essentially from experience, and repetition by trial and error, with the R& D effort being very small. The maturity phase, in the 90s, is very different to the earlier growth phase. The overall context is now much more restrictive and demands that companies develop more aggressive and more coherent strategies. Innovation takes place in a small number of companies and these are only imitated as other companies succeed in penetrating into market segments where that innovation is required. Greater downward pressure on profit margins and less encouraging market prospects make companies more cautious and less prone to risk-taking. The subjective and objective barriers to imitation are now much greater than they were in the past. Innovation stimuli are addressed specifically to firms which are willing to penetrate into new market segments and to undergo the required effort of adaptation. Internal production of new knowledge now depends less on knowledge which is socialised at local level and more on agents and institutions who, by their nature, are in the forefront of research into new product and process solutions, as, for example, technology centres, laboratories, national and international academic research centres, the chemical industry and equipment suppliers. R& D activities play an important role in the generation of new knowledge and the result of the combination of external and internal knowledge in this phase is more codified than before. This means that the need for strict compliance with procedures is a pre-requisite for successful innovation, requiring more sophisticated control mechanisms and more advanced forms of organisation. All these are increasingly incompatible with traditional practices based merely on accumulated empirical knowledge. The relationship between positive externalities and low transaction costs (in particular communication costs) is now less related to geographical proximity and more associated to institutional, technological and economic proximity, involving explicit and formalized communication routines.

The Alalena case provides important evidence on the process which leads to the formation of a technological districts. In this case the technological districts emerges from a typical Marshallian industrial district as the result of a process of induced innovation and introduction of localized technological innovations engendered by the increasing competition of international markets. The division of labor in manufacturing has been progressively complemented and integrated by increasing levels of ex-ante coordination and cioomplementary specialization in the production of new industrial knowledge.

3) Outsourcing plays an important role as a vector of communication flows, especially when large firms rely upon smaller suppliers within the same industry at large for the provision of specialized components which enter new products. Even stronger is the case within subcontracting relations where large firms retain the control of the overall innovation process and induce major innovations, both in products, processes and intermediary inputs and organization, in suppliers. Vertical relations become the context for important technological communication flows that are both forma and intentional and informal. Vertical relations among firms in this context are further enriched and implemented by mobility of personnel from large to small firms. The implementation of new technologies conceived in large firms and actually manufactured by small firms is made even stronger.

The case study on the packaging machinery district of Bologna provides key evidence about the strategic role of vertical relations among complementary firms in fostering the flows of technological communication and hence the rates of introduction of technological change[8].About 40% of the Italian makers of packaging machinery cluster in the Bologna area, that is known as the 'Italian Packaging Valley' The Bologna district is made up of a few leader firms, and about 150 smaller niche producers. In addition, numerous intermediate firms, that are not classifiable as packaging producers, are involved in sub-contracting. The packaging filiere, in Bologna, is formed by about 1,000 mechanical firms, altogether employing nearly 20,000 workers. The empirical research has focused the formation of such a complex and inter-related cluster of firms. The aim has been to identify the main factors which sustaining the development of this unique, heavily exporting (about 90% of the annual output is sold in

[8]By Fiorenza Belussi
7by Joao Ferrao et alii

foreign countries) production system. The finding identify a relatively rapid adoption of technical change among the firms of the district, and a remarkable local formation of technological skills and local knowledge. The research shows that spatial clustering in technological district favours the building of multilayers communication systems, though which technology is developed, shared, and recombined. Within the district, the expansion of the stock of contextual (tacit and codified) knowledge has been particularly related to the constitution of productive networks formed by many external subcontracting firms.

The AutoEuropa (AE) case in the Lisbon metropolitan area also sheds some light on the intentional efforts of firms to activate the vertical communication of technological knowledge within subcontracting relations[9]. The AE project was born in the light of the Single Market and the restructuring of the European automobile industry under pressure from Japanese producers. In 1991 EEC and Portuguese government aid of more than ECU 500 million was approved for Ford and VW to set up AE in the Set?bal Peninsula, which belongs to the Lisbon Metropolitan Area. The total investment amounts to ECU 2,550 million, the largest global investment in the automobile industry in the last few years and undoubtedly the biggest ever inward investment in Portugal. AE produces multi-purpose vehicles (Ford Galaxy, VW Sharan and Seat Alhambra), which are almost all exported to European markets. Direct employment is approximately 3,900 workers and total output reaches 120,000 vehicles/year. Local content levels are 45% of the value of the finished product. Recently, VW took over AE, however continue to produce Ford MPV.

AE is a 'lean' plant: kanban and JIT are used in plant production organisation. Nearby firms deliver under JIT and the logistics system in the industrial park is co-ordinated by one specialised international firm. Proximity here is essential because of the lean production: firms need to be co-localized primarily to secure fast and reliable provision of components. The dynamics of collective knowledge emerges a consequence of such-localization and it is driven by the standardization effort of the main contractors. Many SMEs had the opportunity to supply AE and this gave rise to an automobile regional cluster in Portugal. At the same time, some international firms invested in Set?bal Peninsula to supply the AE plant in a JIT system. The supply chain is organised at three different geographical levels: local, national and international. To become a member of the selective AE system is quite difficult, especially for Portuguese SMEs, which in general have poor organisational and technological capabilities. These are in turn the domains where changes have been most significant. AE has acted as a driving force for innovation in the suppliers chain (AE system). Moreover, public funding and institutional involvement supported supplier firms in the organisational and technological change process required by AE. Suppliers were certified after a rigorous process of evaluation in several domains: product design, development of processes, industrialisation, packaging and support activities. This situation clearly illustrates the need for a codified language between AE and their suppliers. It also shows that AE trusts certified companies and so does not need to carry out systematic quality checks on all the components received into the plant. External and internal codified knowledge dominate the learning processes of supplier firms. Auditing mechanisms, the technology transfer process and the Fordnet EDI system are powerful examples of codified knowledge in the AE system. However, other institutions play a role in the learning process of AE system, like GAPIE and training and R&D centres. Although it is mainly codified knowledge which drives learning processes in the AE system, there are cases of external tacit knowledge in the development of some firms. These processes are geographically 'sticky' and in this sense, they are not easily transferable to other areas. The plastics firms in the AE system manage to combine external and internal, codified and tacit knowledge, and thereby achieve a more powerful position. This helps them to avoid lock-in effects, as they have the bargaining power and the competence to supply other carmakers' assembly plants. Nevertheless, not every firm has the same access or the same communication costs in AE system, as a result of the tier system used by carmakers. It is clear that AE has brought about the spread of external knowledge and technological communication amongst its suppliers, even where there is no geographical proximity. However, geographical proximity matters in the AE system, since suppliers who are located nearby (first type of suppliers) show a very different form of relation with the focal company. For second type of supplier, geographical proximity to AE is not critical for obtaining access to external knowledge. However, most of these firms share localised knowledge. We contend that the first type of suppliers are locked-in, however, and if AE were to face difficulties, these suppliers would close down their facilities, with severe consequences for the regional economy. In contrast, the second type of supplier have a close relation with AE, but do not depend only on this client. AE has stimulated an innovative attitude at firm level enhanced by the network. Clearly, the network amplifies technological externalities in the AE system and thus reduces transaction costs, particularly communication costs. The evidence here confirms that multinational subsidiaries are building important firm networks, and thus are becoming more spatially embedded even in the least favoured regions, as is the case with the AE system in Portugal.

The AE case in the metropolitan area od Lisbon provides evidence on an alternative path to the emergence of a technological district. here the technological district appears to be the product of a process of vertical disintegration of a large company and induced creation of a web of subcontractors. Comlplementarity and coordination in the generation of new technological knowledge is achieved by means of quasi-integration where large companies play a key role in organizing the division of innovative labor.

4) The coexistence of large and small firms within technological districts appears a critical element for many reasons. Communication is enhanced by variety and diversity among agents. Opportunity for exchange of information between firms is larger, the larger is the difference of channels in terms of typology of knowledge accumulated, scope for its implementation and sets of competencies. Small firms can benefit from faster decision making and entrepreneurial reaction than large firms. The latter can access the advantages of economies of size in conducting research and development activities. Firms, according to size, differ with respect to the typology of knowledge they produce and the knowledge they use. Large firms have a clear advantage in the production of codified knowledge while small firms excel in the accumulation of tacit knowledge. In turn however large firms mainly depend upon external tacit knowledge and small firms on external codified knowledge. The interactive coexistence of large and small firms is vital in enhancing the accumulation and circulation of technological knowledge. The key role of large firms within technological districts marks an important difference with respect to the Neo-Marshallian approach about industrial districts which emphasizes the role of small firms together with their homogeneity in terms of size (Antonelli, 1986; Becattini, 1979 and 1987).

The different role of small and large firms in the localized production and use of codified and tacit knowledge is shown in the case of Flanders Language Valley (FLV) in Belgium[10]. The basic research department of a large multinational company (Lernout & Hauspie Speech Products, L&H) is at the technological core of this cluster. Through licensing the attracted small firms use this common source of codified knowledge and with their fast entrepreneurial reaction they complement it by developing a broad range of applications. Subsequently, the

[10]By René Wintjes

created favorable communication conditions induced innovative linkages between the attracted SMEs. Like the Silicon Valley role-model, a strong pilot firm, venture capital, education and most of all the informal networking were critical to the development of FLV.

L&H got many requests from clients wanting access to their R&D core, the language laboratory in Ieper. Buying the codified knowledge with a license did not seem sufficient to integrate technologies. Face-to-face communication was considered necessary due to the complexity of the projects and this forced them to come to Ieper. The idea of creating a cluster in Ieper was born. The FLV Fund provides venture capital to stimulate starting and fast-growing young firms specialized in the technological field of language and speech technology. The screening policy typically canvasses the opinion of L&H and other participating firms in order to validate the technological and commercial capabilities of potential candidates, and to see if there could be some common interest or complementarity. It keeps the firms closely linked and progressively linked, since each new firm must have something to add. An other criteria to select firms to invest in is the interest they show in locating in Ieper, 'forcing' a clustering process. At present there are some 26 small, fast growing, innovative FLV firms which are supported by the incubation services of the FLV Foundation. The first firms have located at a 65-acre business park and another hundred additional companies (foreign as well as indigenous) are expected to join. Companies 'find' each other at FLV to their mutual advantage. They learn from each other and benefit from developing and using common pools of resources in proximity, e.g., companies find employees in the 'collective pool of labour' created by several education and training programmes.

5) Triangular communication along vertical filieres and horizontally across sector plays a special role in this context. Firms active in the same industry rarely share technological information and do not participate into direct horizontal communication. Horizontal intersectoral communication is made difficult by the sheer lack of information about the potential needs of firms active in seemingly un-related industries. The case for indirect communication however is often found when two firms in the same industry share a common supplier or customer. The common supplier or customer then becomes a node in a triangular flow of communication where two communication flows pass into a switching node. The same dynamics take place across industries when a supplier or a customer acts as a switching board for communication flows between two firms in two different filieres (Bianchi and Enrietti, 2000; Belussi, 2000).

The case of the automotive district of Torino confirms the role of the interaction between large and small firms in technological communication and eventually in the co-generation of new technological knowledge[11]. In the Torino district there is a long-standing tradition of specialisation in car manufacturing, dating since the end of the XIX century with the following strong points: 1) car manufacturers and suppliers are geographically close to each other, especially important during the design and development stage of components; 2) a close-knit network of subcontractors (engineering, moulding, die-casting); 3) highly developed and qualified styling and design sector; 4) high quality of work force; 5) availability of a vast range of components.

The evidence here suggests that during the last 30 years, the production activities related to the car industry in Piedmont have evolved from a car-based industrial area dependent on Fiat into an actual technological district characterised by the intensification of technological

[11]By Ronny Bianchi and Aldo Enrietti

relations between firms so as to generate new localized knowledge. Fiat Auto reduced the level of vertical integration not only in manufacturing but also in many service activities previously considered crucial (design and development, administration and transport). Highly idiosyncratic and specific know-how, strongly related to a company, became more and more industry-specific and became available to suppliers and later to all the firms in the technological district. The reduction in the number of suppliers and the switch from suppliers of single parts to those which can provide modules and systems pushed component manufacturers to innovate (especially small and medium-sized firms) and to get involved in design and development. This has been possible because at local level there was already a network of design and development firms that worked on Fiat contracts, and which thus transferred their skills to Fiat's suppliers. Furthermore, Fiat went through a bout of restructuring which resulted in a reduction in employees. Labour resources and know-how, previously internal to Fiat came onto the market, becoming available for the local system. As the number of prime suppliers was reduced and they concentrated on supplying Fiat with modules and systems, the quality of the subcontractors increased. Strengthening the local supply system has also resulted in less dependence on Fiat, through the development of new market outlets, i. e. supplying Fiat's competitors, (especially abroad), other sectors of the automotive industry and diversification into other sectors. Indeed, the process of learning by interacting with Fiat and learning by doing in the car industry made it possible to pass from tacit knowledge to the absorption and eventual recombination of external knowledge in the district thus making it easier to enter foreign markets. There is an increase in the number of players who help to build up localized knowledge in the area. The growing importance and number of designers leads to the growth of a series of schools and institutes supporting this activity. Design and development activities become more important in the district both because of autonomous growth and because of outsourcing by Fiat. Firms no longer depend only on Fiat but they are able to grow abroad, too. A decisive step towards the spread of innovation in the technological district, above all for SMEs, was made when the Fiat Research Centre became independent and opened its doors to the outside world. Fiat Research Centre has played an important role in the spread of innovation through the programme of transferring innovation to SMEs. One of the key elements in the shift from the automotive industrial area to the technological district has been the evolution of communications technology within the district itself. The change that occurred could be described as the passage from a situation in which technological information was centred on Fiat to one in which it becomes a collective asset within the production meso-system and technological district with the formation and development of "triangular communication" at various levels. By means of "triangular communication" different companies make contact with each other not only directly but also through a series of common customers and suppliers which act as "tacit intermediaries" with the implicit function to enriching the possibilities of technological exchange.

The formation of a technological districytin the Torino area here appears to be the result of a process of progressive externalization from a single large company of a variety of knowledge-intensive activities, embodied both in the production of components and in advanced services. This process seems very much compementary to the oppossite progressive internalization of the competences of the marshallian industrial district at the onset of the XX century . The large corporation here seems to be the intermediary between the Marshallian and the technological district.

6) Industrial dynamics and specifically entry rates of firms are one additional and important channel of technological communication. Entry of either newly established firms, or cross-entry of incumbents in other industries and other regions enhances the technological communication because it provides opportunities for techniques and information well

established in one industry and region to be disseminated in others. This is typically the positive effect of the entry of multinational companies. Newly founded firms on the other hand typically represent the opportunity for new ideas to be tested and hence communicated in the market place.

The case study of Flanders Drive (FD) provides clear evidence on the key role of industrial dynamics and specifically on the role of the strategies of multinational corporations in a regional context[12]. This case explores the attempt to protect the automobile manufacturing industry in Flanders (Belgium) by changing the balance between simple parts manufacture and assembly on the one hand, and design and engineering on the other. Several of the region's first tier (mostly foreign) suppliers with internal R&D capabilities initiated innovative clustering under with the FD initiative (Flanders Development Research and Innovation for Vehicle Engineering). This private cluster initiative was recently joined by a public one. The public-private strategy aims at increasing innovative capacity and generating technological communication which would anchor the internal and external knowledge generating processes in Flanders. It is thought that the 'stickiness' of localized knowledge will provide a stronger footing for Flanders' automotive industry in the increasingly 'slippery' global production space.

With more than 12 manufactured vehicles per 100 inhabitants, automotive output in Belgium is the highest in the world. The Belgian automotive industry is concentrated in Flanders and most of its output originates from the 4 (formerly 5) foreign car manufacturers. While manufacturing employment in general has been decreasing, employment in the automobile sector, has been roughly constant. Since 1994, however, the number of vehicles produced has decreased. Among other factors, fierce global competition, excess capacity and European integration are to blame. Employment in the Belgium automotive supply industry is increasing, but the assembly plants purchase largely from the country in which their parent firm is located (Renault from France, Volvo from Sweden and Ford, Opel and Volkswagen from Germany). The response of the car manufacturers to increased global competition concentrated on reducing production (especially labor) costs and supply (or external production) costs. Past policy in this sector had focused on providing subsidies to parts manufacturers and assemblers to influence their (al)location decisions and promoting market and logistical relationships between local assemblers and suppliers. With public support suppliers have located on parks in the immediate vicinity of the plants, but mostly for logistic reasons and not for innovative ones. Due to a lack of in-house innovative capacity, the proximity does not seem to facilitate the generation of technological change. The internal knowledge base of the assembly plants concerns the implementation of new process technology; product and process innovations come from their home base R&D facilities. On the supplier parks foreign investors have build warehouses rather than factories in order to minimize the sunk costs associated with these investments. The suppliers may have to relocate when contracts end and a new car model is assigned to the assemblers.

In 1998 Renault announced the closure of its plant in Vilvoorde. It raised serious concerns about the automobile industry in Belgium. As manufacturing becomes more and more footloose, and production and supply efficiency can be created in many places, the associated investments may not have the desired territorial rooted effect. One possibility arises through innovation, taking advantage of the general stickiness of innovation processes. Generating localized knowledge is made difficult by three things: many disparate technologies and types of knowledge are involved, neither the foreign car assemblers nor most of the suppliers in

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[12]By René Wintjes

Flanders have an in-house innovative capacity, a lack of external innovative capacity due to a poor public innovation infrastructure and a lack of inter-firm communication.

A small group of mostly foreign first tier suppliers paved the path to the dynamics of localized knowledge. Thanks to their own in-house capability to introduce technological change they had survived past restructuring and relocation forces (on internal and external markets). Realizing this, these firms are attempting to strengthen this defence against rationalization imposed by head offices and external restructuring forces (e.g. market saturation, excess capacity and European integration). Using the localized interaction between the complementary internal (and external) production and innovation resources, these firms want to anchor their ability to introduce technological change in the region by promoting the creation and use of knowledge external to each firm, but internal to Flanders. They claim this would enhance their chances of surviving future rationalization, restructuring and relocation phases even further, since next to their internal innovation capacity the embeddedness in 'regional innovation capacity' represents a valuable assets, which can hardly be transferred or duplicated elsewhere.

In the aim to increase the external innovative capacity in Flanders they founded FD. These first-tier suppliers were not closely connected to the car plants in Flanders: on average only 3 percent of total sales are to clients in Belgium (17 percent of their purchases comes from Belgium). The motivation to take or join the networking initiative was not based at corporate but rather on subsidiary level. Several of the founding people (all R&D managers) appeared to know each other from the University of Leuven. Some had worked in more than one (research departments) of the associated firms. Before the FD initiative the firms rarely communicated with each other, except that they all were clients of LMS (Leuven), the initiator. Its expertise in measurement and analysis technology represents one of the main common technological interests. Thanks to active networking the firms are now better aware of what others have to offer and which problems or interests they have in common. It increased the use of external knowledge resources among the member firms. Other organizations like the University of Leuven and WTCM, a Collective Technology Center in Leuven, became associated members.

This case study evidence confirms that agglomeration of production is not enough to induce localized knowledge; material investments to reduce costs of production and supply may have a limited anchoring effect; investments in in-house innovative capacity roots firms and protects against restructuring and relocation forces; subsidiaries of foreign suppliers may have strong incentives to invest in in-house innovative capabilities and in external, regional innovation capacity. The evidence of this case shows that public-private efforts to build an innovation system embedded in a region appear a more attractive policy option than ever larger subsidies in order to keep firms within the region and attract new ones from outside.

The formation of a technological district seems to be the result of a bottom-up process of progressive coordination and complementary specialization of a variety of independent subcontractors and providers of intermediary goods to upstream large corporations, driven by the increasing pressure of international competition and by the risks of exit of large local players.

7) The features of the local innovation system in terms of knowledge infrastructure. The level of the local academic infrastructure and the degree of interactivity with the local business

community play a major role. University and the academic community at large do spill scientific and technological externalities as a large empirical evidence has shown. The access to such externalities however appears easy only when (and if) the academic and the business community have established clear ways of interaction and communication as it is often the case in the US institutional set-up. In this context the flow of postgraduate students from Universities to firms is high as well as the funding of academic research activities by firms. The localized interaction between education and training and production are all the more useful to enhance the rates of technological communication within a system. The alternance of training spells along the productive life of individuals can greatly favor the circulation of information within an economic system. The traditional concentration of education in youth with limited access to retraining eventually in life clearly reduces the chances for technological communication to take place (Geuna, 1999).

The regional concentration of the research labs of industrial firms adds on to the opportunities for smaller firms located in the proximity to take advantage of technological externalities at low communication costs and enhances the probabilities that firms can take advantage of interstitial technological opportunities that are considered internally as second best and yet can lead to profitable technological innovations for smaller firms. The regional concentration of research laboratories can also become the institutional device for symmetric communication externalities among large firms to take place (Howells, 1990; Quéré, 1994; Patel, 1995; Mansfield, 1991; Bania and Eberts, 1993, Jaffe, Trajtenberg and Henderson, 1993; Audretsch and Stephan, 1996; Feldman and Audretsch, 1999).

Along these lines the evidence of Sophia-Antipolis, the first Science Park in Europe, confirms both how important is the local scientific infrastructure and how slow and complex is the process to building an 'artificial' scientific agglomeration[13]. The Sophia-Antipolis experiment is preparing to celebrate its thirstiest birthday. It appears today as an important centre of high technology in Europe, and is presented as a success of territorial development, with 1164 firms and 20530 employees on site. The case study analyzes the experiment represented by Sophia-Antipolis, i.e. the artificial creation of a Science Park as a tool of both implementation of a national innovation system and regional development. The history of the experiment helps to identify the main steps in this path.

The take-off of the experiment is exogenous, and characterized by externalization of resources in large firms. Indeed, Sophia-Antipolis has been created in a region with no industrial or industry tradition, in order to develop an alternative development, less dependent of the seasonality and uncertainty of tourism, the main local activity. As a consequence, the project developed on the idea that the French Riviera could attract activities linked to research and high technology. Sophia-Antipolis results as a private project led by Pierre Laffitte, a director of the Ecole Nationale des Mines de Paris, and rapidly transferred to the public sector because of financial constraints. The project has been supported by the decentralisation policy of large French firms and research institutions, and by an active marketing strategy directed to international investments which matched the multi-nationalisation process of the eighties. In addition to important general advantages (international airport, climate), the involvement of France Télécom allowing nodes of international network in the area induced a significant process of growth. As emphasized, this process does not reflect endogenous cumulative processes and is totally driven by strategies external to the site. The initial clustering of activities has been somewhat casual, but quickly two main technological activities emerged: information technologies (65% of employment) and activities related to life and health sciences

[13]By Christian Longhi and Michel Quéré

(20%). The clustering of technological activities through the location of external activities on the site created a mass-effect and induced further activities. The experiment changed indeed progressively in its nature during the eighties, with a relative slowdown of location of R&D units of large firms. The assimilation of the experiment to a technopolis came from this period, with the growth of training and research activities, the formation of high qualified resources needed to feed the emerging labour market, and the growth of service activities. This period is indeed firstly marked by the development of the University of Nice in Sophia-Antipolis, and the creation of schools of engineers mainly dedicated to information technologies. The potential of public research has also been reinforced, all the main French research bodies are present in Sophia-Antipolis (INRIA, Ecole des Mines, CNRS institutes, INRA), and France Télécom has developed a strong potential (Theseus, Eurecom, Cnet). The result has been the emergence of a local labour market of high qualified resources, mainly in information technologies, and an increase in the links between research and industry through students. Secondly, the service activities have grown importantly since 1982, as a result of a catch up process. Different populations of firms have emerged, dedicated to services for people working or living in Sophia-Antipolis, to specialized services for technological firms, which have largely contributed to the strengthening of the experiment, and also firms, numerous, locating in Sophia to capture the image effect but without local links. Thirdly, high tech small firms have begun to appear in the project. They were partly spin-offs of the main research institutes (INRIA, Mines), partly start-ups locating in Sophia-Antipolis to sustain their growth and benefit from the clustered research potential.

These trends have been important, but they have not changed the main characteristic of Sophia-Antipolis, i.e. a location dominated by R&D units of large firms, much more benefiting from external than internal links.

Real changes have emerged with the trouble faced by the project at the beginning of the 90s, as a result of the crisis of computer sciences activities which was the engine of growth of the project, and because of the shift in the global strategies of large international firms driven by the search of specific, more than general, advantages. The remaining fragility of the project, depending of external resources, has accentuated the consequences in Sophia-Antipolis. A new strategy of development was necessary. Contrary to the take-off of the project, no public policy emerged, but the resources accumulated locally allowed new dynamic processes to develop in some activities. The recovery of the project has indeed rapidly followed the industrial take-off of information technologies that has emerged in the mid-nineties.

This brought, first, a change in the nature of growth, dominated by endogenous processes compared to new location of external activities. Second, the dynamic factor has been the multiplication of new firms, both start ups and spin-offs from large firms as a result of their downsizing. This process has continued, as a result of the externalization of activities developed by these large firms, which allowed the emergence of an actual 'technological district'.

The size distribution of firms, with the lack of medium firms able to back a secured productive environment, attests the remaining fragility of the project. However, this evolution from an exogenous to an endogenous-driven process of growth can be thought of as the result of a significant development in localized knowledge. Both individual and collective initiatives are at the origin of this development. Individual initiatives are often a result of the crisis and organizational changes, employees as well as firms have been threatened to relocate. In fact, many employees in the plants and local headquarters of multinational companies did not want to leave the area. This induced people to explore new productive opportunities rather than to accept internal mobility. The result has been on the one side the multiplication of SMEs and the development of new relations between firms (between SMEs themselves as well as between SMEs and large companies through the development of specialized subcontracting); on the other side, a change in the strategy of large companies, which had to open and develop co-operation to impose Sophia-Antipolis as a relevant location in Europe. Two main actors of the experiment, France Telecom and INRIA have devoted resources to sustain these new processes. The result has been the development of collective initiatives which have supplemented the lack of public response to the crisis. The main movement has been the multiplication of professional associations on the site, to share experiences and problems, and find collectively answers to the new challenges. Historically, the first associations were devoted to lobbying for new public infrastructures; they evolved towards attempts to increase the internal co-ordination between economic actors in Sophia-Antipolis, and to favour the development of technologies and innovation. The first attempt, 'Telecom Valley', was aimed to give a specific label to the site and impose it as a location of telecommunication activities in Europe. It resulted in involvement of large firms in the technological animation of the site, which began to open and share resources. Different other associations have been created since, all devoted to the development of technologies and innovation, through co-operative processes between the different actors involved. This collective process has been a major force to develop the emergence of localized knowledge and specific advantages in Sophia-Antipolis. The recent location of new large firms seems to attest the viability of these new endogenous processes.

The development of high tech SMEs and the development of localized knowledge have helped to complement the Sophia-Antipolis resources with those of local external partners, mainly IBM and Texas Instrument, which were largely disconnected from the local economic environment. From 1995 for example, the restructuring of the group allowed the local Texas-Instrument unit to become more autonomous and responsible for a specific product family including a variety of digital signal processing applications). As the latter is mainly concerned with GSM and UMTS applications, the strategy of the unit changes, according to its local environment. Today, it can be considered that Texas-Instrument has largely contributed to expand the distinctive capabilities of the Sophia-Antipolis project inside and outside its frontiers. Texas-Instrument is one of the key-members of the Telecom Valley association; it has significantly increased its productive implications in the local environment by establishing a complex network of relationships with some companies belonging to the Sophia-Antipolis project or to its surrounding, and helped to develop regional relationships with firms located in industrial parks near Marseille. Sophia-Antipolis appears as a source of new technologies sustaining local development and innovative activities. These developments show that the experiment has today the capabilities to develop local technologies based on specific advantages, and can play effectively an important role in terms of regional development. Links with traditional activities of the area, like tourism for example, could be found to reinforce the local industrial context. Bur still, public initiatives seem to be necessary to favour the co-ordination of the different actors, firms and public bodies, like the Conseil Général or the Chamber of Commerce, and to develop strategies to anticipate the possible consequences of the growing specialization of the site. Indeed, activities where localized knowledge has not been able to emerge endogenously are declining, like health sciences, despite technological and market opportunities could exist locally.

The formation of a technological districts in the case of Sophia-Antipolis seems to be the eventual outcome of the artificial creation of a science park implemented by the entry of new smamml firms and the progressive integration in the local industrial system.

8) The distribution and quality of knowledge-intensive business service industries have important effects on the economic system in terms of innovative capacity. An increase in the exchange of tacit knowledge, made possible by the local supply of the services of consultants and advisers, improves connectivity between agents, sharing learning experiences and creating learning opportunities, and thus advances receptivity. Similarly, improved business services, in terms of distribution, capillarity, competence and access, improves the interaction between tacit, localized knowledge and increasingly larger amounts of generic knowledge, and in so doing is conducive to the accelerated introduction of technological and organizational innovations and solutions specifically tailored to a firm's individual needs. An active local supply of knowledge-intensive-business-services can stimulate technological outsourcing and hence the demand for knowledge-intensive-services by small and medium-sized firms in particular. Knowledge-intensive-service firms activate important flows of triangular communication among firms and are often the result of the vertical disintegration of large companies with the spin-off of specialized service units within large corporations which eventually search for larger markets than intracorporate ones.

The case study on the Tagus Park, the Lisbon Science and Technology Park, located in the metropolitan area of the capital city of Portugal provides a good example of the positive effects of the localized interaction between knowledge-intensive-business-services and the local industrial base. This case also provides an excellent example of the outcome of a new generation of industrial policies aimed at strengthening the weak technological base Portuguese industry[14]. Although the initial stimulus came from the State, Tagus Park, like most of the technological infrastructure projects of the same period, was developed with a view to stimulating partnerships between public and private bodies, including State entities and local authorities, universities and research institutions and major firms from the financial and telecommunications sectors. The Park's management company was formally established in 1992, and the Park itself began to operate in 1995, when its central services were set up and the first companies opened their offices there. This is therefore a very recent infrastructure project, in existence for little more than 3 years. Although growth within it has been remarkable, there are still only about 100 companies established there. Companies in the 'Centro de Inovacao Empresarial'(Business Innovation Centre) account for most of this figure: it includes new companies in an 'incubation' phase and other small and medium-sized firms, most of which relocated from other areas around Lisbon, taking advantage of the special terms on which technology-based SMEs were able to set up in the Park.

Some of the institutions which were to serve as anchors for the project, like the Instituto Superior Tecnico (IST), which is the most important Portuguese university institution in the engineering field, and the Instituto de Engenharia de Sistemas e Computadores (INESC), one of the main entities involved in research and development in information technology, electronics and telecommunications, have not yet moved to the Park. The relative infancy of the project and the delay in bringing in the R&D anchor institutions are crucial features of the present profile of the Park, where small and very small enterprises (80% of the total), very young companies (70% were created in the 1990s) and the IT sector (63% of the companies are involved in computer software and hardware, other electronic-related activities and communications) are clearly dominant. Companies located in Tagus Park exhibit a high degree of propensity to change. Most of the firms have been involved in new products and services and in changes in the sales and personnel areas these last three years. For more than 60% of these companies these changes are tied in with a clear increase in investment. Relevant resources are devoted to R&D activities. However, research activity takes a clear second place

[14]By Joao Ferrao et al.

and development activity involves primarily the improvement of existing products and processes (adaptation and upgrading of available solutions in the more innovative segments of the world market).

The ways in which firms learn and innovate partially reflect the processes and conditions which led to their formation. Most of the firms were formed by professionals who had previously worked in the public innovation system (universities, state research laboratories) or in multinational companies, either in Portugal or abroad. By a process of spin-offs, small groups of professionals with high degrees of technical knowledge and a good relational capital but in general little prior experience of the business world, decided to create a firm which would be clearly innovative in the Portuguese market.

For those who came from the public innovation system, the ability to establish an effective dialogue between a not very market-oriented university system and a not very demanding market is a decisive factor. Success lies in being able to develop innovative products in the light of academic criteria but also in ensuring from the onset that these products have the sanction of the marketplace, and will therefore be fairly certain of being a commercial success. Research activities dominate, in a context where project partnership, public and Community funding and market sanction are crucial success factors. In this case, small innovative firms play an essential role as information and knowledge brokers, acting as a bridge between different cultures and practices and contributing to closer links between the public system of innovation and the marketplace. For those with previous experience in multinational companies, there is more of a tendency towards direct integrated consultancy, developed specifically in accordance with each client's specific needs. This group therefore favours development activities over research activities. In these cases, being a Portuguese agent for innovative products and equipment enables consulting firms to benefit from a permanent learning process with first-class world-level manufacturers and suppliers and gives them a long-lasting and stable relationship as maintenance and consultancy service-providers to highly demanding clients. In both cases, firms use the Internet intensively, not only as a source of information and knowledge, but also as an important means of communication in order to find suppliers, partners and quality clients.

The 'park effect' on the innovative capacity of firms located within it depends on the way those firms perceive and use externalities made available by Tagus Park. For some enterprises, the Park represents a good investment in terms of real estate or a good option in terms of public image, but not a source of innovation. For most of the firms the Park-effect is related to the opportunity to be in contact with and to absorb new technologies based on business interaction stimulated by physical proximity. A strong importance is given to socialisation, inter-organisational co-operation and business interaction as direct innovation factors. The most competitive firms are in fact those which are able to recombine a wider and more complex range of sources and types of knowledge.

The management of Tagus Park has a crucial role as an agent of informal channelling and intermediation activities during this initial stage of the Park's development. Informal and bi-lateral contacts between firms in the Park and organisations (public institutions and companies) of possible strategic importance for helping these firms to increase their competitiveness, are one way of overcoming the inherently high costs of communication. In recognising the importance of learning by interacting, this informal channelling and intermediation function developed by the management of the Park has also helped firms in another learning process - that of recognising the advantages of inter-institutional and inter-firm relationships.

9) The quality of local communication infrastructure. The emphasis on the role of technological communication makes it possible to appreciate how the characters of the present wave of innovations in communication technology, itself a product of the clustering of localized and complementary technological changes, are likely to interact with the rate of introduction of localized technological changes and to enhance the general levels of innovation capability of firms. The quality of local communication networks can play an important role in favouring the division of innovative labor when high speed data communication can take place and high-definition images can be easily transferred among research units. As a growing evidence confirms digital communication can complement rather than substitute for person-to-person communication. Technological districts with high-quality communication infrastructure can benefit of the spiralling interactions between digital and vis-a-vis communication (Antonelli, 1999).

The Alcatel case-study provides interesting evidence on the key role of advanced communication infrastructure in developing localized knowledge from a network of companies located in its immediate surrounding[15]. Alcatel-Cannes is specialized in the manufacturing of satellites. The satellites market has evolved toward a much more competitive market where the negotiation procedures, the costs of satellites, their expected performance, their technical specifications are more and more differentiated. Product market changes induced deep modifications in technical specificities, in human skills and resources, and required a specialization in the core competencies of the company which externalized some of its industrial activities. A great number of high-qualified workers were laid-off. A significant number of them decided to create their own company, acting as a sub-contractor for their initial enterprise. They cover two main types of technological activities: mechanics and mechanical engineering on the one hand, computer and software engineering on the other hand. Most of those partners are small and medium sized companies located in the surrounding of the Cannes business unit and interacting with it in the aim of developing technological and innovative capabilities. The case study shows that the introduction of an advanced close-loop LAN became the integrating device in order to achieve higher levels of quality control and reduced time lags in the innovation process in the sub-contracted activities. In order to belong to the LAN, initial training within Alcatel, has been one of the key-factors. This was thought of as a necessary condition for implementing trust between each small company and the Alcatel unit to economise on transaction costs. As a consequence, the members of the network benefited from specific training possibilities about new technological development. Interestingly however, this network is an enlarging: Alcatel is only one of the crucial participants. The main technological leaders of the region in data processing (IBM, Compaq, Gemplus, Microsoft, Amadeus, Texas-Instrument, Bay Networks, Nortel) came on board to share the same network with parallel cooperative effects through co-operations with the same SMEs. Each of the large companies also contributes to increase the innovative potentials of their sub-contractors and increases their efficiency by providing them with different types of information. As a result many subcontractors belong to more than one network so as to share experience, information, knowledge from one large company to another. Through individual mobility tied to task-forces or on projects-characteristics, those companies develop their expertise and their capabilities to create generic knowledge, generic in the sense it can be re-used for other problem-solving contexts. The sequence here is very interesting: the hard network (the LAN) favored the diffusion of network-type of organisation which contributes to spill-over technological innovations from an enterprise to another. This process also allow to understand the interactions between generic and localized knowledge:

[15]by Adel Ben Youssef and Michel Queré

specific applications are derived from some generic technologies for each of the dominant large companies and in turn provide opportunities to generate new general applications. In many cases they also contribute to select the most efficient technologies. This case study also helps to see how the development of information technologies changes considerably the nature of the relationships: whereas, previously, the relationships were clearly limited to dedicated problems, the increase in 'on line' communication and exchanges changes the rules of the game and evolves the nature of the relationships towards a more continuous problem-solving interaction. This increases the difficulty for the partners to specify the characteristics of the co-operation's contents, their own responsibilities, the technological limits of the co-operation, and so on. Lastly, this induces higher tensions on the appropriability of the skills, competencies and technologies involved in the co-operation. As such, the development of intranet possibilities makes more fuzzy the frontiers between the partners and, as a consequence, stresses the importance of the property rights appropriability associated in the co-operation process.

To sum-up, this case shows how hard networks, in a context of industrial re-organization, became the main vector to implement an actual collective context for implementing localized knowledge. Co-operation through networking allowed for mutual benefits and mutual technological interdependence.

The Alatel case provides evidence about the key role of advanced communication infrastructures together with enhanced division of labor in high-tech activities as focussing devices in the formation of a technological district.

10) Professional associations and industrial clubs provide important opportunities for technological communication to take place and should be considered key factors in the definition of the organization of an industry. Ever since the path breaking analysis of Richardson (1972) professional associations, including collective research institutions, are seen as basic institutions that facilitate the diffusion of relevant knowledge within limited regional spaces and are conducive to a variety of forms of tacit exchanges of information and know-how. Locally technological cooperation is often the result of implicit strategic actions taken by co-localized firms to increase connectivity and receptivity levels and hence technological communication (Dorfman, 1983; Watkins, 1991; Saxenian, 1994; Clarysse, Debackere and Van Dierdonck, 1995; Hagerdoorn, 1995).

The Packaging Valley case-study provides strong evidence on this matter[16]. The Champagne-Ardennes area is located in the south-east of Paris. It is the fourth region in France for the relative importance of packaging in terms of total employment. It concentrates around 250 companies, not only specialised in handling and processing of materials, but also in design and manufacture of packaging robots and automated wrapping processes. Such concentration of packaging activities and professional skills makes this region particularly relevant for the study of the dynamics of localized knowledge. In this case the role of local policy-makers is very important. Local institutions engaged in an active policy aimed at promoting local co-ordination among firms companies in order to develop local innovative behaviours. The Packaging Valley Association was founded in 1993 to implement this co-ordinating objectives together with many local research and development institutions.

The analysis of this productive system has made it possible to identify two distinct groups of firms in this industrial pole: the packaging and accessories manufacturers (population A), and,

[16] By Agnes Grenard

the packaging equipment manufacturers (population B).The productive behaviours of these two groups of firms appeared to be very distinctive. The packaging products and accessories manufacturers make up the most important population (63%) of the Packaging Valley (118 companies). The productive activities of these firms consist of handling and processing materials (plastics, paper, wood, glass, metal, etc.) in order to produce various packaging products. The emergence of the packaging equipment firms seems for a large part the result of the bankruptcy of an important, highly mechanised packaging group. The collapse of this group lead to the creation, at the end of the 1980s and at the beginning of the 1990s, of new highly specialised local SMEs. The latter progressively become the main channel of co-operative behaviours that locally lead to more formal partnerships and collective innovations.

The evidence suggests that the accumulation of a collective pool of localised technological packaging knowledge in Champagne-Ardennes comes mainly from the local public institutions acting in research and development. In fact, it is mainly the existence of professional associations, such as the Packaging Valley Association and the existence of public organizations specialised in packaging education, research and development (like ESIEC and ADRIAC) that allowed a localized knowledge dynamics to emerge and to become significant. More especially, although price and product differentiation competition among packaging products and accessories manufacturers (population A) is significant, partnership-type of relationships exist within the 'A' population in the case of productive overruns and the between the 'A' population and their customers. The relationships between the companies within the 'A' population and local training and research institutes seems to encourage those local effects. For the 'B' population, markets are essentially national and international and firms use more advanced technologies. These companies are specialized in specific market segments with high levels of both vertical and horizontal complementarity. Systematic efforts of the local institutions favored local inter-firm relationships leading to information, human and materials exchanges and competence sharing.

In sum this case shows how the variety of actors, their complementarity and the dynamic role of local public and collective institutions generated major local effects in terms of packaging and wrapping competencies.

11) In this context the strong regional content of the new emerging markets for disembodied technological knowledge where firms sell and buy patents, know-how, technological licences seems to pave the way to the increasing specializing of regions and firms in the generation of dedicated technological knowledge. The search for licences, patents, and know-how seems far more successful when locally based, within a technological districts and implemented by co-localized relations. The combination of informal relations and formal purchase of licences can help firms to access external knowledge available on international and domestic markets. Such external technological knowledge can be recombined and contribute the internal elaboration of tacit and codified knowledge with evident advantages in terms of efficiency of the intramuros R&D activities.

The case study of the Eindhoven-Venlo region provides valuable insight into how a particular transformation of the innovation process affects individual companies and the regional mechatronics system as a whole in the South-east of the Netherlands[17]. The transformation involves out-sourcing engineering activities in order to increase the access and use of external

[17]By René Wintjes

knowledge in the region and build up internal knowledge resources. The study spotlights one of the major high-tech companies in the region, located in Venlo, Océ. This producer of high performance copiers and printing systems functions as the core of the office machine cluster in the region. Océ's goal was to upgrade regional suppliers from jobbers into 'main-suppliers' so that most of the engineering could be done by closely located suppliers while Océ played the role of system integrator. Suppliers saw an opportunity to reduce the extent of (production) cost competition by increasing their own innovative competencies. Océ and the regional Innovation Centre initiated the Knowledge-intensive Industrial Clustering (KIC) programme. As a joint public and private policy the KIC programme aims at localising and embedding Océ's codifying process into the region in order to take advantage of the externalities stemming from this codifying process. As a policy instrument it is designed to re-arrange the regional innovation system by supporting regional suppliers to generate, absorb and cultivate technological externalities that stem from Océ's strategy to out-source engineering activities.

For Océ out-sourcing is not a recent phenomenon. As a head-tail company it is focused on R&D, assembly and after-sales. Over the last ten years the budget for R&D more than doubled. Océ buys 90 percent of all parts and components from other companies. Besides out-sourcing manufacturing activities the company also wants to out-source engineering and remain focused on product development so as to gain freedom in design and choice of technology for parts and components: dis-integration reduces irreversibilities. Océ transformed its innovation process from a linear towards a more interactive one where the separate, but complementary, phases, from basic feasibility studies to market introduction, were more and more integrated and overlapping each other. This implied for suppliers closer involvement in engineering before they started to produce components. Therefore, with the introduction of the Early Supplier Involvement (ESI) strategy, Océ started to involve suppliers in the engineering process in a one-on-one relationship. Suppliers from the region seemed able to compete with more remote firms: Océ discovered that East European subcontractors were less effective than expected. Especially the R&D-unit had underestimated the transaction and transformation costs, and among those especially the costs of technological communication. It was not the physical distance that made it difficult to involve subcontractors into the innovation process, but the costs technological, cultural and institutional distances.

With KIC Océ takes it a step further outsourcing most of the engineering out to a group of co-operating suppliers in the region.

The KIC concept originates from the regional Innovation Centre (IC) in Venlo. One of the members on the board of the IC was the director of Océ's R&D business-unit. Based on experience in innovation support to small firms in the region, IC consultants selected the firms. In a typical KIC project 3 to 4 suppliers work together, co-engineering a lab model of a new module into a manufacturable one. A typical KIC-firm is a small or medium-sized skill-intensive firm, whose innovative capacity traditionally consists of tacit knowledge accumulated by many years of internal learning from experience. Firms belong a variety of industries: metal processing, electronics, plastics processing, glass, ceramic, software or plating. The organisational flexibility based on the informal character of the co-operation among the small firms impressed the R&D unit of Océ. As Océ became more and more convinced of the concept (helped by the attraction of funds) it gradually took over the organising role of the IC. The project evolved and several problems occurred: more and more Océ selected firms it already knew, so few new communication channels were created. The proposed training has not been implemented. Océ and Philips tried to tackle the problem of conflicting CAD systems among firms by increasing the compatibility between the different systems with promises for KIC firms to actually produce the modules they had engineered; during the first projects there was a lack of communication between Océ's R&D and Purchasing department, leaving suppliers stuck between the head and the tail. The number of participating firms per micro-cluster decreased. An important role in the early clusters has been played by knowledge-intensive-service-firms such as engineering consultants which acted as interfaces between OCE and the other large companies and the small firms.

In spite of problems and the evolution in the nature of the clusters, the KIC firms have indeed undergone a transformation. They have grown rapidly, typically more than doubling in employment. Further, they have grown from almost zero to an average of 6 percent of their labour force being structurally engaged in R&D. A strong point of the KIC concept and in fact the whole region is the loose dependency of suppliers on the main firm. Due to the relationships with end-producers in several sectors, they fulfil an important role in making the spill-overs between sectors as well as between firms possible.

This case study shows that the change in allocation between internal and external knowledge resources is not an easy (costless) change. The restructuring of knowledge-generation-process (internalising and externalising, integrating and dis-integrating) requires intensive communicative interactions between heterogeneous knowledge resources. The KIC programme is a learning and transformation programme. By doing, the firms build up codifying and de-codifying capabilities, learn how to exchange tacit knowledge and learn how to reorganise their internal innovation processes accordingly. The KIC concept refers to dynamic efficiency by increasing innovative and communicative capabilities, enhancing their role in socialising technological externalities within the region.

4. CONCLUSIONS AND POLICY IMPLICATIONS.

4.1. PROMOTING COLLECTIVE KNOWLEDGE IN REGIONAL-LOCAL NETWORKS THROUGH POLICY AND INSTITUTIONAL ARRANGEMENTS: CONSIDERATIONS ON THE FORM OF PUBLIC INTERVENTION[18]

Where and how to link policies for improving technological communication? Besides the normative proposals emerging from economic and social theories of innovation, some policies are already addressing directly issues connected to enhancing technological communication systems and innovation, policies that should be taken into account when giving advise. Secondly policy analysts insist on the existence of policy sequences or trajectories that evolve and develop following mainly political forces and dynamics. Historically the main stream of actions referring to technology or having impact in it was S&T policy, however other policies or actions at local level appear to have been critical to create channels that support "technological communication" and the transmission and use of collective knowledge.

We have to remember that it is traditional in policy analysis to examine public actions and policies with an implicit focus that considers the concept of policy domain (Burstein, 1991), or policy areas and sectors, as the building block for their study. Policy domains are seen as components of the political system organised around substantive issues or as a system of coherent actors that participate in the design, development, and implementation of the specific policy. Those studying policy domains define them in terms of, at least, three sets of

[18]by Luis Sanz Menendez

characteristics: The issues that define a policy domain are seen as sharing inherent substantive characteristics which influence how there are framed and dealt with. In fact, the development of policy analysis is the result of this process of ìinsulationî of coherent parts of policy action such health, energy, agriculture, etc. However more recently instead of placing the emphasis on the inherent qualities of policy domains, researchers insist that policy domains are largely socially constructed by those active in politics. They insist on the organisational basis of policy domains, where we could see them as a set of organisations concerned with a set of substantive problems, which are each taken into account as they formulate options and work for their adoption. The third relevant aspect is related to the cultural or ideational basis of policy domains, because when organisations define particular conditions as problems or develop policy options, they are influenced by the ideas they have about how society works.

The conclusion that public action proceeds within relatively self-contained policy domains has two important implications for the analysis of policy change. The first one is that all those analysing policy domains either hypothesise or assume that the domains are characterised by 'causal autonomy', thus is policy outcomes are affected primarily by forces within each domain. Second, assuming that policy processes within domains are indeed causally autonomous, then general society-wide conditions will have little direct effect on policy (though they may constrain policy developments or affect them indirectly by influencing organisational or cultural developments within domains). Because policy change is determined by forces within each domain, no single factor underlies policy change across domains, nor is the an unified elite controlling most or all domains.

With this analytical background one interesting issue in policy analysis is to account for the mutual influence and interaction between the different policy domains as a force of change. In fact when we look the evolution of policy domains in detail, we observe that the boundaries between them are blurred, that raising problems and new approaches in a policy domain help to transform the visions of other policy areas. In effect, policy frames diffuse from one domain to another and policy transfer occurs between different levels of governance.

For the substantive policies associated to technological communication and innovation an intriguing case is emerging. We have observed in the last decade processes of transformation and evolution which give us some perception of convergence between policies in historically and well defined policy domains. On one side, science and technology (or research) policies have evolved into more broad innovation policies, that include such elements on diffusion or technology transfer policies, consideration of SMEs and approaches that see regions an localities as part of the framework in of support of technological development. On the other side, regional development policies are changing from exclusive actions aiming to build up physical infrastructures and providing incentives to attract external investment to the locations, to a new generation of policy actions oriented to improve the pool of technological competencies, to help to consolidate the local SME with a orientation to external markets, to train the labour force and to create local innovation capabilities.

We are observing a process of convergence or co-evolution on the policy proposals and actions that are reshaping the boundaries between policy domains; and this process is especially active in what refers to technology policies, regional policies and SMEs policies. The convergence occurs around the ìinnovation and technology diffusion oriented policiesî. In that way normative proposals emerging from socio-economic theories are only partially relevant in the explanation of empirical policies, that is the policies that really exist, which respond to other forces, and dynamics, mainly political. Basic to our understanding of policy is the underlined model of policy development and implementation. There is a broad formulation

(Hall, 1993) that accounts for policies we need to consider: the interest of the actors involved, the institutions that emerge from social interaction and the ideas that actors use to frame the problems. But at this point we will not enter into the analysis of the forces that explain policy change and evolution. It is our claim (Borres & Sanz-Menendez, 1999) that most of this dynamic could be explained at the EU level for the emergence of new ideas and causal models in social sciences that influence and develop the policy discourse.

Our proposal is that what is fuelling this process of exchange and interaction between policy domains, and then policy change, is a threefold dynamics: The first two could be considered endogenous to the policy process: First, is the impact of new analyticly approaches in economics and other social sciences. The new ideas, the new causal models understanding innovation contribute to the redefinition of the problems and the policy frames. Actors in the policy domain adopt the new ideas as the solutions to cope with problems. Second, professional bureaucracies are key actors in the process of policy learning. Monitoring and evaluation of the existing policies are also sources of policy change. Additionally interaction between bureaucracies corresponding to different policy domains are key elements in the diffusion and exchange of policy practices. In continental Europe bureaucracies are also key actors to mobilise the coalition supporting the new views. The third one is exogenous, and is represented by the emergence of new actors and new political players in both policy domains. A big transformation has happened in Europe in the last decades. Now many scholars describe the European governance system as a multilevel one, in which the European institutions and the regions and localities, gaining political power because the process of devolution and decentralisation, have a main role in technology, innovation and regional policies.

We observe empirically that there is a "convergence" in the rhetoric of the two policies, that are trying to define strategies for improvement of innovation: Research and technology policies and regional development policies. If we were interested in the explanation of this process of convergence probably it would be a good idea to consider some arguments of the relevance of the "ideas"(Hall, 1993; Goldstein, 1993; Goldstein and Kehoane, 1993), the role of the "policy frames"(Schˆn and Rein,1994), or the emergence of epistemic communities (Hass, 1992) in the European policy making.

At this time we are not aiming to provide the normative propositions or the ìappropriate policesî, but rather just to understand some of the dynamics of policy change in Europe, and especially to analyse different aspects of the innovation policies aiming regional development, because it is in this area where new forms of public intervention become closer to the polycentric model as mentioned in the previous section as one of the new type of arrangements for policy intervention.

Our interest here is not study if there is a process of convergence or not, thus if it is blurring the boundaries between policies and the emergence of a new empirical model of policy action more appropriate to the normative model, but just to reflect on some issues of the underline model of implementation that some policies have.

Looking at science and technology policies or at regional innovation policies, regardless that both evolves in a direction of promoting innovation and diffusion, we observe -probably because of the relevance of specific policy trajectories, two diverse types of strategies, especially in what refers to the issue of building collective strategies that could give us some insights on distinctive and participatory arrangements for implementation of policy.
Here we will describe and reflect on the promising changes that we can observe in the evolution of a whole policy domain at the European level: the regional policy. But what is our

interest here is the new ways of implementation that redefine the role of public authorities. The new trends of development in the way in which the problem of regional development and social cohesion has been addressed in the last years show us the increasing relevance of the innovation as a central concept for regional economic development, mainly used to cope with the problems of less favoured regions.

The changes in this policy domain are very significant because they diffuse and spread all over the different European levels of governance, national, regional and even local governments. In the Treaties of the Union, European regional policy refers mainly to the reduction of disparities among regions in Europe; the Treaty of the European Union has ìeconomic and social cohesionî as one of its main pillars (article 130a and ss.).

Historically the model of action in regional policies emerging from theory and implemented strategies in countries and at the European level have reflected a concern for the appropriate level of physical infrastructures and more recently on the qualifications and skill of the labour force. However after a period of experimentation (for example STRIDE initiative) and analytical development (Ewers & Wettman, 1980) a new focus has emerged in the regional capabilities for innovation.

An emergent official discourse in the new regional policy orientation may be clearly identified, for example, when analysing the content of the Commission communication on 'Reinforcing cohesion and competitiveness through research, technological development and innovation' (COM(98)275, 27 May 1998), but what is more important is that innovation has become formally one of the priorities for the new generation of regional development programmes of the European Union. The new Guideliness 2000-2006 (CEC, 1999; CEC, 1998) entitled ìEconomic and social cohesion: growth and competitiveness for employmentî is based on two broad principles: i) identification of integrated strategies for development and conversion and ii) the creation of a decentralised, effective and broad partnership.

The new approaches taken by the Guidelines reflect the recent evolution of European regional policy, because a new understanding of regional competitiveness problem (Cooke, P, 1999; Cooke, P. et al., 1998), a new approach to the policy actions to promote innovation capabilities (including actions such as: Promoting innovation with new forms of financing -e.g. venture capital- to encourage start-ups, spin-outs/spin-offs, specialised business services, technology transfer; supporting interactions between firms and higher education/research institutes; encouraging small firms to carry out RTD for the first-time; networking and industrial co-operation; developing human capabilities; etc), and a new way of addressing the intervention from the public side. It is this last issue, the approaches to create a sustainable collective system, instead of a traditional top-down implementation, is what interests at the moment.

New approaches in the role of public action have been called; that of a broker/mediator and facilitator (Schienstock, 1994) among economic agents in order to create the right conditions for collective learning to happen. And we will briefly review the pilot experience, that in fact is embedding a new form of understanding in the role of public sector intervention.

Consequently, European regional policy aims at the creation of the right economic and institutional conditions in a given region for a sustained and a sustainable economic development process which creates economic opportunity and jobs that might increase regional income. The new approach is organised around the idea of helping regions to improve their abilities to learn and to increase their innovation capabilities, as a way of better adapting to the rapid changes in economic conditions.

As it has been mentioned, the main objective of innovative actions under the European Regional Development Fund (ERDF) is to influence and improve European regional policy in order to make it more efficient in terms of its content and policy action. These innovative actions rely on ëthe principle of helping regions to help themselves through initiatives designed to mobilise local knowledge in a process of collective social learningí (Henderson and Morgan, 1999).

Regional Innovation Strategies (RISs) are part of innovative actions developed under art. 10 of the ERDF. RIS are also about inter-institutional co-ordination and establishing linkages and collaboration networks among the different elements and players of the regional innovation system. RIS are a tool to strengthen Regional Innovation Systems (territorial systems that efficiently create, diffuse and exploit knowledge than enhances regional competitiveness) in less favoured regions. However, the way in which they develops we think create a case for institutional arrangement for policy development that could be considered as a specific case for supporting technological communication systems at local level in a sustainable way.
RISs have key methodological principles based on demand-led and bottom-up approach (See Landabaso, 1997 and especially Landabaso et al 1999). RIS is clearly demand-led (focusing on firmís innovation needs, SMEs in particular), thus is consistent with the new approaches of technology policy (OECD, 1991, 1992; Soete and Aroundel, 1993) and bottom-up (with a broad involvement of regional research, technology and innovation actors) in their elaboration. Innovation strategies include not only technology considerations but also issues regarding human capital, research and education, training, management, finance, marketingÖas well as policy co-ordination among regional policy, technology policy, industrial policy, R&D and education policy, etc. RIS have been based on public-private partnership and consensus (the private sector and the key regional technology and innovation players are closely associated in the development of the strategy and its implementation), thus regional administrations are involved, in partnership with the relevant key regional innovation actors, in the design, implementation, monitoring and follow-up of the exercise; RIS aims to be integrated in a way to link efforts and actions from the public sector (EU, national, regional, local) and the private sector towards a common goal. RIS appears as strategic planning measures based on an extended partnership and subsidiarity

These principles reflect an approach quite different than the traditional policy proposals including visions that are top-down or centralise, which is a feature of some of the traditional regional policy. Consistent with the issue we, in other project, have argued that ìinnovation policy is rather (and increasingly) a matter of networking between heterogeneous (organised) actors instead of top-down decision making and implementationî and it follows that 'successful' policymaking normally means compromising through alignment and 're-framingí of stakeholdersí perspectives' (Kuhlmann et al., 1999, p. 12).

Thus when talking about policy recommendations, in addition to the substantive content of the proposals for intervention it is necessary to consider the forms and conditions of implementation in support of sustainable system.

What RIS strategies have demonstrated is clear that the public sector, especially regional governments can play a major role in articulating and dynamising a regional innovation system, understood as the process of generating, diffusing and exploiting knowledge with the objective of fostering regional development. The public action is helping to overcome the collective action problems and to lower transaction cost, articulating and linking regional actors (firms, technology centres, universities, business service providers, etc.) and matching (innovation needs with knowledge supply) in search of synergies and complementarities among the different actors, policies and sub-systems which integrate a regional innovation system. In this sense, the regional government as evidenced by the RIS experience can and should play an important role as a catalyst, a facilitator and a broker in the articulation of the regional innovation system.

It is reported (Broekhold, Arnold and Tsipuri, 1998) that the involvement of the key players in Operational and Steering groups of the RIS project has contributed to the formation of social capital in the region by encouraging participation, trust and civic co-operation. In terms of Colemanís (1988) three forms of social capital have developed: The level of trust of key actors was enhanced by co-operation at both senior practitioner and executive levels. Information channels were opened up both horizontally between organisations and vertically within organisations. And finally, norms were established at two levels with the possibility of sanctions for non-cooperative behaviour at any one level.

Implications of the institutional approach to sustainable policies.

Our mode of analysis to understand when proposals for developing policies will be sustainable involves a radical change in the traditional approach to public sector intervention. Instead of presuming that creating one authority is necessary for solving public sector problems, other possibilities can be explored.

This mode of analysis can be used by scholars, citizens, government officials and others to identify the complex set of incentives that exist in any particular setting that relate to the technological communication processes.

At the beginning, we made a simple assumption that actors and organisations who are expected to invest resources (including their own time and labour) in the development and maintenance of a collective good must perceive that the benefits they obtain exceed the costs of the resources they devote to this task. The existence of aggregate benefits that exceed aggregate costs is not, however, enough to elicit individual efforts at a sufficient level to obtain these benefits. This is particularly true when actors may obtain some portion of the benefits produced without expending much individual effort. The free-rider problem is now well accepted as a characteristic of many situations in which actors can withhold contributions toward the production of joint benefits but cannot be excluded from enjoying the benefits one they are provided. If all knew that beneficiaries would follow the free-riding strategy, everyone would receive fewer net benefits overall.

Partial analysis focusing exclusively on the "policy prescriptions" and on the free-riding have been used frequently to support policy recommendations to ìstrengthenî national or regional level government institutions . Such strengthening is often interpreted as training civil servants in technical and managerial skills and helping to increase the power of the government in relation to competing interest.

The problem with the over-centralised approach is that in practice such policies help increase the power of centralised governments in relation to competing interest without making much impact on the sustainability of the policy mechanism.

Even this kind of strategies based on partial analysis frequently produce counterproductive outcomes. Among these are the potential for rent seeking that occurs as soon as the free rider problem is solved through coerced financial contributions to a common, public treasury. Once taxes are imposed, they become a fixed cost for everyone, except those who are willing to risk exposure and punishment for pursuing illegal task avoidance strategies. Individual net benefits can be legally enhanced, however, by lobbying for special entitlements or other forms of disproportionate benefits supported by the common treasury. Wealthy and powerful individuals or groups are likely to have resources necessary to influence the allocation of public funds and obtained economic rents from large-scale infrastructure project. Thus, highly concentrated benefits can be generated ñbenefits that exceed the cost of rent-seeking activities. The resulting cost are thus spread across many individuals who are less motivated ñand usually less able- to prevent the disproportionate allocation of government funds and entitlements.

The problem could be additionally exacerbated in absence of institutional arrangements that facilitate and encourage beneficiaries of localised collective knowledge to find ways of participating, financing, operating and maintaining they own projects. Incentives to engage in rent seeking exist in all countries with large public sectors, and when proposing measures to improve the development of localised technological communications systems a clear vision of the need to generate a sustainable strategy is as important as the selection of policy tools and actions. Futhermore, from what we have been describing, the new experiments on regional innovation strategies (RIS) have opened the door to consider the need to mobilise the actors and even to negotiate with them the course of action.

Therefore new policies have to include not only the prescriptions of what to do but also how to do it in order to guarantee success and sustainability.

4.2. Addressing the creation, operation and exploitation of localised technological change [19]

Theory argues that innovation performance should be stronger if innovative activity is geographically agglomerated. Many theoretical analyses, from different perspectives, have come to the conclusion that innovation clusters are a real and important phenomenon, and the INLOCO case studies supply further empirical support for this view. The growing importance and prevalence of these clusters raises the possibility of policy intervention. Regions, nations or continents fearing they suffer an innovation deficit might look for policies to promote innovation through agglomeration. Areas without a deficit might look to their futures as innovation leaders and ask about the ongoing health of their clusters of innovators. It may be that no intervention is needed; it may be that clusters are well-served by market forces and laissez-faire is the right approach. On the other hand, though, it may be that there are things vital to the health and dynamism of a cluster that the market cannot or does not provide. If this is the case policy intervention may be appropriate. Regardless of the final conclusion on that question, the issue of innovation clustering is important enough that it deserves examination from the policy point of view. This paper does that, and provides a discussion of policy options that should be considered by a policy maker interested in promoting the formation, growth and health of localised technical change.

[19] By Robin Cowan and René Wintjes

In principle policy aims at a change in behaviour. Policy makers can address behaviour of firms directly via subsidies and projects or indirectly via the provision of 'hard' or 'soft' public infrastructure. Providing subsidies addresses the behaviour of firms directly, and in the neo-classical approach is seen to do so by affecting the cost-benefit calculations of the agents. A subsidy for R&D or for location-specific investment affects decisions to engage in R&D or where to locate or invest. In a more evolutionary approach the reasoning behind policy incorporates a learning effect. In this respect subsidies for R&D can provide a learning experience. Policy support can start a process, such as the agglomeration process in a region or the innovation process in a firm. The argument for policy than becomes temporal; timing and the ex ante conditions become important. Policy becomes pro-active rather than reactive.
If what a cluster and its firms need and have to offer is well articulated and commonly agreed upon, the market mechanism may be sufficient to communicate supply and demand, so public policy is not relevant. However, the importance of tacit knowledge and informal communication, combined with difficulties for single, isolated agents to predict the path of technological change suggests there is a pro-active and inter-active role for public policy addressing the creation, operation and exploitation of localised technical change. Moreover, within a learning-to-innovate framework the appropriate mode of intervention is an interactive and not a linear one. Regional policy makers can take part in the localised discussion and help to articulate the needs of a region. Instead of a linear redistribution of resources from the centre, cluster policy may support each region's existing strengths and back its self-organising capacity. The case-studies suggest that the main target group are the SMEs in the cluster — they keep the technical change local, they provide much of the growth potential and they provide the local flexibility. In many cases SMEs provide the spill-overs between sectors and they seem to be essential in restructuring, extending and renewing the cluster both in the course of normal operation and in response to crises.

Successful localised technological change takes place when a local system of innovators exists and creates synergies. It is also true, though, that any innovation in a region takes place in a wider context, namely the innovation system of a larger geographic or economic area such as a nation or continent. Thus policy here must take on a systemic nature, considering interplay among many different elements. There is need for a cluster policy system within which regional initiatives exist and are fostered, but by which coherence in the larger system is furthered.

Policy concerned with localised technological change, by definition, implies a concentration of resources. It does not necessarily imply, however, a small number of European innovation clusters in whereby the innovation activities of Europe would be concentrated in a small number of areas. Rather, it implies a more industry-specific concentration in which the innovation activities of specific industries would be concentrated. This approach does imply a strong need for a co-ordinating role from the centre. If many clusters are to exist, there is a risk of duplication of activity, and a risk that synergies are lost if clusters that would complement each other are not somehow linked. At the regional level, policy must have a strong focus on informal interactions of agents within the region. All analyses of successful localised technical change emphasise the importance of informal communication among firms and individuals, both as a way of transferring tacit knowledge, and as a way of creating coherence regarding technology, social norms, and business practices within the cluster. Coherence on all three lines is vital to success, and only emerges if there are frequent, strong informal interactions among agents within the region.

Policy tools:

We can make a broad distinction between generic and specific policy instruments or tools. Generic, horizontal instruments provide support available to all. For example, from a macro-socio-economic point of view R&D is a good thing, but the market under-supplies it. Thus, based on arguments concerning the social rate of return, policy stimulates R&D in firms, stimulates public R&D, and finances universities. These sorts of policy tools are usually part of the national policy domain.
Specific instruments address firms in specific sectors, of a certain age, size, location, et cetera. Policy concerned with localised technical change is mostly associated with specific instruments targeting specific firms in a well defined territory. Each cluster will need a different kind of intervention, so a different mix of tools may be appropriate. There are sound arguments, though, to set some objective criteria in selecting the beneficiaries, and the regional and National/European "toolboxes" may contain similar instruments.
It is important, however, to prevent a policy tournament. As regional policy makers promote agglomerations of technical change within their own regions, the national and European centres must act to minimise duplication of public investments, and overcome a lack of selection as every region or nation protects its own cluster(s). The public centre can set the rules for a private tournament, where markets do not function very well. But failures have to be acknowledged and it must be possible to have winners in the end.

Underpinnings

Our basic understanding of the localisation of technical change rests on two ideas. The first is Marshallian externalities; the second is the importance of tacit knowledge.

Marshall (1920) argued that industries tend to agglomerate production for three reasons. The first is the value of a thick local market for skilled labour. If there are many firms in the same industry in one location, there will be a large associated labour force similarly located. Any firm wishing to hire labour has, potentially, a large pool to draw from. This lowers the costs of changing production to meet demand, both in terms of quantity, and within limits, of quality. The second source of "Marshallian externalities" is the market for specialised inputs. Local suppliers of specialised inputs will be able to capture any increasing returns in their production if there is a large local demand. Similarly, if input suppliers are relatively large, this facilitates their innovative activities, since the investments made to innovate will be amortised over larger output volumes. Both of these effects will reduce input costs. Finally, Marshall discussed the importance of knowledge, and the notion that if an industry is locally large, the flows of knowledge will be greater, and that this will reduce costs of production. In Marshall's analysis, agglomerations of industry had lower production costs due to the presence of these factors. His main idea had to do with the production of manufactures, but it is clear that with appropriate alterations, these factors apply to the production of innovation as well. Indeed, the third factor is one that has been emphasised in recent literature on innovation, and transformed in the literature on tacit knowledge.

Tacit knowledge in now seen as a vital input in the innovation process (Pavitt, 1987; Cowan et al. 1999). Some knowledge is codified, that is, it is recorded in some way, either in written documents, on magnetic tape or disk, or on some other medium. This knowledge, to someone who is able to read the language in which it is "written", is freely transferable. This is the form of knowledge that has held pride of place in discussions of research, innovation and R&D

policy for many years. The openness of this knowledge, its transferability and non-rivalrous nature have led to public support of basic research and the patent system as means of overcoming the market failures inherent in a good which is expensive to produce but inexpensive to reproduce; infinitely extensible (any number of people may have the "same" piece of knowledge, like the Pythagorean Theorem); and difficult to market (since a buyer can only evaluate what a seller is offering by looking at it, and by this act alone the buyer can learn enough that he need not buy the knowledge). What has been emphasised in recent years, though, is that codified knowledge is far from sufficient. Tacit knowledge is a necessary part of any information activity, either learning or producing knowledge. One property of tacit knowledge is that, unlike codified knowledge, it is difficult to transmit among agents. Long distance transmission is virtually impossible, and most transmission takes place in face-to-face interactions. This, then, is a very strong source in localised technological change. If tacit knowledge is important in innovation activities, and diffusion of knowledge is central to a strong innovation system, then a system organised to facilitate diffusion of tacit knowledge will, in general, have stronger innovation performance than one that is not. But if tacit knowledge is only transmitted face-to-face, then good diffusion will only take place among agents located near to each other physically. Agglomerations of innovators should have relatively high rates of innovation. As we discuss below, (and in the appendix) mere agglomeration is not enough; there are many factors that change an agglomeration of firms into an innovation cluster. Mere agglomeration or concentration of public support may not be enough either. This distinction between agglomerations and clusters creates a positive, and more complex, role for policy.

Policy Background

In this section we set out some of the background for the detailed policy discussion that follows. We discuss different policy goals and aspects of the dynamics of localised technical change and of policy that must be considered in a general way before turning to the details.

Creation, Operation, Exploitation

When examining policies aimed at promoting localised technological change, three issues are immediately relevant. First is the issue of creation of the cluster or agglomeration. Given the view that localisation will improve the innovative performance of some industry, what steps are necessary to make a cluster form? Second, a cluster is more than simple geographical proximity of like firms. Clusters have internal dynamics which affect how they perform as sources of innovation. How then can we induce good performance once a geographical agglomeration has formed? Finally, how can a cluster be exploited? A well-functioning cluster will raise employment and income in the immediate vicinity. But presumably the goal is larger than this. One hopes that an innovating cluster creates benefits that are felt throughout the economy, both through effects on consumers and on other firms.

Regions and the Centre

These three questions point to a tension that runs through cluster policy, namely the tension between the (national or continental) centre and the regions. Cluster formation and operation can generally be addressed with regional policies — attracting firms to a region and creating appropriate infrastructure are largely regional initiatives, since the geographical extension of the activities is very circumscribed. These issues have received most of the attention in policy analysis, partly, no doubt, because of the positive way they resonate with ideas of subsidiarity. The third issue — exploiting a cluster — is of a bigger scale than a region; it is clearly a national or continental concern. Integrating the cluster with the rest of the economy and the rest of the innovation system cannot be accomplished by regional initiatives alone. Explicit analyses of cluster policy, focussing on regional initiatives, have largely left aside exploitation as an issue.

While exploitation may be an important entry for central policy making there is another important role for the centre. Every region in Europe would like to have a thriving high-tech innovation cluster. But there are many more regions than there are glamorous industries. This raises the very real risk of competition among regions for clusters in particular industries. Particularly in view of the fact that most European clusters are significantly smaller than the size at which agglomeration externalities turn from positive to negative externalities, the centre must be aware that regions can have negative effects on each others' attempts to build successful clusters. Preventing this sort of tournament is an important, and politically difficult, activity of the centre.

Cluster Life-Cycles

Any cluster, like any living organism, will evolve as time passes. Clusters are initially formed, they grow, and they operate successfully or die. With any phase, there will be an associated measure of success, and different policy rationales. When a cluster is forming, a significant success criterion is whether firms join. When a cluster is established, we can consider whether its firms are growing and innovating successfully. A second criterion for mature clusters is whether they contribute to wealth creation outside the immediate vicinity of the agglomeration. As the central activity of the cluster changes from increasing the number of participants to the growth of incumbent participants, for example, not only do the criteria of success change, but also the pre-requisites for it. Thus if policy is appropriate, policy itself will have to change and evolve as a cluster evolves. Market or systems failures early in the life of a cluster are very likely to be different from those later in its life. The notion of setting a policy once and for all must be abandoned. The life cycle of a cluster is clearly related to the issues of creation, operation and exploitation. We must emphasise, though, that the mapping is not direct — one cannot simply assume that exploitation (policy) begins when operation (policy) ends and that operation policies only need be considered after the cluster has been created. The three aspects inter-mingle over the life of a cluster.

Important Factors in Cluster Success

Drawing from the INLOCO case studies of localised technological change, we can identify several general factors that contribute in an important way to the success of an innovation cluster. We give a brief summary of these factors before turning to policy per se.

Human Capital

All innovative activity involves knowledge and human capital. The extent to which specialised human capital is important varies among industries, with the high tech industries demanding the most specialisation. Clusters in which innovation demands specialisation are likely to find, initially at least, a local shortage of skilled labour. In the short run this can only be met by immigration to the region. In the medium and long run this human capital can be locally generated by the development of appropriate education and training institutions. But educational facilities are notoriously prone to free-riding. If a firm or group of firms attempts to set up private institutions, it will pay any single firm to stay outside the group, but to hire the graduates of the institutions at slightly higher salaries than can be paid by the group which is supporting the institution. Scope for policy intervention is obvious.

Social Norms

Closely related to human capital is the issue of social norms. There are two aspects here. Virtually all of the case studies of innovation clusters show that the participants in the cluster, while competing with each other vigorously in some areas, simply do not compete in others. For example, in the textile districts in Italy, the norm appears to be that firms compete on design and innovation, but not on price, quality, or "any of the myriad factors that might give one firm a *temporary* advantage over another" (Temple, 1998, p. 276, emphasis added). In the Flanders Language Valley there is no competition regarding the basic speech technology; competition concerns the applications. See also the case of Taguspark: "the very strong social condemnation which exists in relation to poaching of top staff" (Ferrão et al. 1999, p.41). Restrictions on competition of this sort are common. A closely related issue has to do with information disclosure. Clusters are successful when there is a significant flow of tacit knowledge. But extremes of behaviour will be self-defeating: total disclosure of all knowledge removes incentives to generate innovations; total secrecy eviscerates the clustering advantages. Partial disclosure will be optimal. But with partial disclosure comes the temptation to free-ride — listening but not contributing to conversations about technical issues. This sort of activity cannot be regulated either legally or by the market, so there must be a norm regarding how much and what sort of information is disclosed, and what happens to those who refuse to disclose. Again, this is a sort of circumscription of competition.

The second aspect of social norms is a form of compensation for market failure. When technological change is rapid, the market is not good at predicting the future since the salient aspect of the future does not have to do with prices, but rather with technological trends. If markets are not effective in future-looking activities, how is a cutting edge firm to ensure that there will be supplies of the inputs it needs, and demand for the products it produces? One solution is to integrate vertically. The other is to belong to a cluster of small and medium sized firms that share a (technological) vision of the future. This vision is created and maintained through interactions, both formal and informal, among the agents in the cluster who share ideas, rumours and possible technological paths, all of which coalesce into a common view of future technological trajectories.

Communication Infrastructure

The success of an innovation cluster is driven to a very great extent by the transmission of knowledge and ideas among the cluster members. Clearly, there must be well-functioning avenues of communication for this to happen effectively. There are two types of infrastructure involved here. One is the physical and organisational infrastructure to support the new ICTs. These are the technologies firms use to communicate orders, plans and projections rapidly among themselves. The second is the physical and social infrastructure. This infrastructure is used in the informal interactions among firm employees, which have been documented in many of the INLOCO case studies as vital in creating cohesive norms, and common views about the future.

The case of the Packaging District in Bologna, for instance, highlights the importance of multiple informal, social communication channels where entrepreneurs and 'professional skilled workers' meet, like the local associations of entrepreneurs, training centres like the Aldinini Valeriani Institute or the testing laboratories.

The case of Sophia-Antipolis mentions several clubs and associations which co-ordinate local initiatives. The "Club des dirigeants" for instance, informally groups the main executives of the local units of large companies. They discussed their strategies, problems and opportunities and the association traditionally served as a lobby towards public actors, that is, it converged and channelled their complaints about the insufficient level of infrastructures, later the objective evolved towards the promotion of localised knowledge among their partners. The Persion association is a similar organisation but only for academics. More recently, also some thematic oriented associations like the "Association Telecom Valley" serves to structure informal, social interactions.

The case of Packaging in Champagne shows the importance of, amongst others, the Packaging Valley Association as an avenue for local communication. But, we can also point at the importance of the meetings of the association of automotive suppliers in the case study of Flanders DRIVE, where the informal discussion of the former meeting set the formal agenda of the next meeting.

Business Infrastructure

Many studies show the importance of specialised business services to any innovating industry. Feldman (1994, p. 54), for example, emphasises the importance of providers of knowledge on accounting, regulations and standards, marketing, testing, financing, and commercialisation. The presence of these services in a relatively small region contributes strongly to the rate of innovation in that region. In the case study of Alcanena's Tanning District for example, we have witnessed the initial importance of the technical services provided by a concentration of representatives of multinational chemical companies. The provision of services, though, can suffer from the chicken and egg problem — if there are few demanders of the service, it will not pay to provide it, but if essential services are not available in a region, no potential demander will locate there. Over-coming this inertia problem can be facilitated by active policy making. Of particular concern in this regard are financial services. Venture capital financing makes large information demands on the capitalist. Consider the problem of a new cluster, in a new location, with a few new firms, and in the most extreme case, with new a technology. The (almost total) lack of information implies that established venture capital firms will look elsewhere first for investment opportunities. Thus the issue of creating the sort of venture capital needed to finance the early years of a new cluster can be difficult. Public-private initiatives have been successful in this regard, and the Flanders Language Valley Fund could be considered exemplary.

The Policy Domain

This discussion permits us to present the policy domain diagrammatically. The three issues of creation, operation and exploitation serve as the immediate goals of any policy intervention; and policy can be made either at the level of the region, or centrally, by national or continental bodies. Figure 1 relates these axes to various proximate policy targets. It indicates roughly when different aspects of policy will become important, and the levels at which these policies will be implemented. It is important to note that while "cluster life cycle time" is suggested by the ordering of the elements, it should not be interpreted literally. As stated above, there is no tight mapping between creation, operation and exploitation and the age of a cluster. The timing indicated here is only suggestive and a very approximate generalisation.

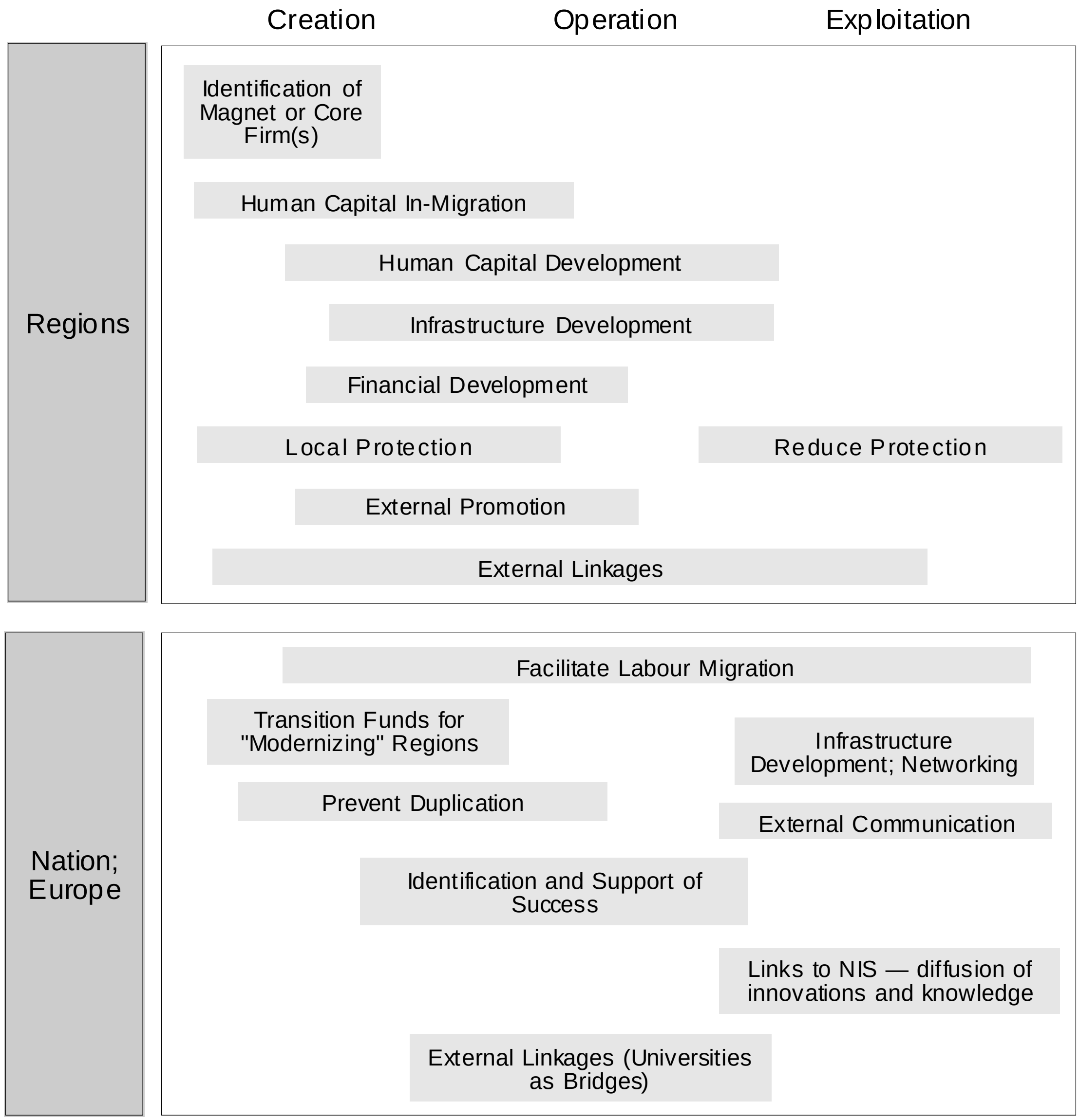

***Figure 1*: A Policy Map for Localised Technological Change**

Below we present possible measures that could be taken by policy-makers at different levels. Not every policy is appropriate to every agglomeration of innovators. A policy maker must use his judgement to identify bottelnecks or systems-failures in particular situations and use policy tools appropriately. Figure 1 can be used to relate different options to each other and to see how they might interact in terms of timing and objectives. We will organise the discussion according to the three aspects of policy, namely cluster creation, operation and exploitation.

Cluster Creation

As a cluster forms, it encounters typical difficulties and needs. Some are simply unavoidable frictions in the creation of any new structure; others can be addressed by policy. As always, policy can operate both at the regional level and at a more central, national or continental, level.

A general conclusion that can be drawn from the INLOCO (and other) case studies is that creating an innovation cluster as a green field investment is extremely difficult. Successful attempts to create innovation clusters from scratch are rare; most successful clusters begin

with a pre-existing magnet, typically a core firm**.** Thus we do not address policies aimed at creating a cluster where there is no possibility of a magnet or core firm.
We saw , for instance, some aspects of these difficulties in the cases of Taguspark, Sophia-Antipolis, and AutoEuropa. Attracting firms does not seem to be the most difficult part (although, for instance, attracting AutoEuropa as a green field investment cost the EEC and Portuguese government more than ECU 500 million) but without some pre-existing local advantage or magnet to build on, it is very difficult for policy makers to create the local linkages and interactions which are needed to induce localized technological dynamics. Even locating a university as a sort of public magnet, does not seem to be enough, as in the case of Sophia-Antipolis. It seems that Sophia-Antipolis needed a crisis to select the cluster members out of the initially attracted firms and to identify some kind of a magnet (ex-post). In the case of Taguspark the planned location of a university might not be enough either. Local discussions seemed necessary in both cases to identify whether there was a magnet or how to create one. In the case of AutoEuropa we have witnessed some difficulties in having a dominant green field core to build a system of localized technological change. "Buying" a core-firm that selects cluster members via a certification programme, had to be accompanied by innovation support to local firms from public institutions (like GAPIN) in order to transform them into potential candidates for the AutoEuropa network.

Regional Policies
Local Magnets. It is extremely difficult to create a cluster ex nihilo. Thus the work of a regional policy maker begins only when the foundations of a successful cluster already exist and have been identified. A young cluster, like any young living organism, is fragile, but may have large potential. Identifying this initial success and potential is a difficult and risky task. Organising studies and discussions can be the first task for policy makers. Before actual support in the form of promotion to attract resources (firms and human resources, funds for infrastructure) can begin, the magnet must be articulated, and a vision of what the cluster would be like has to be shared with the actors involved.
A typical cluster begins with a core firm (or small number of firms) which sees innovation as a major part of its competitive strategy.[20] Many firms satisfy this criterion, but not all are candidates for local magnets. For example, a vertically integrated firm will not, in general, need a cluster surrounding it to pursue its strategy successfully. Firms that are not vertically integrated and which need innovative suppliers and customers will act as core firms; the presence of such a firm provides the possibility that a cluster might form around it. (See for example the case of AutoEuropa). Part of the vision of the cluster's future will include the strategy of the core firm. How will its technological strengths and advances contribute to the growth of a cluster? What are its plans or strategy for local technology diffusion? One answer is through local buyer-supplier relationships and out-sourcing of innovative activities. (See for example the cases of AutoEuropa, Alcatel-Aerospace, Fiat's automotive district of Piedmont, and Océ.) Another way to diffuse knowledge is through licensing. Technology that is licensed, particularly if preference in licensing is given to geographically localised firms, can create a strong incentive for firms to migrate to the region, or to start up there. (See the Flanders

[20] Perroux (1950) was one of the most influential proponents of the role played by core firms. From the 1960s onwards policy makers have been interested in attracting a "firme motrice" as a "pôle de croissance". The location of a large basic firm was thought to bring growth which could be retained locally via the four polarisation- or multiplier-mechanisms (technological, pecuniary, psychological and geographical). The arguments were mainly based on clustering of production. This focus on production did not always bring success. For instance, locating large chemical and steel industries in peripheral regions like "Mezzogiorno" in southern Italy did not bring the desired local linkages. The risk of creating "cathedrals in the desert" or "white elephants" is a serious threat.

Language Valley case.) But local technology diffusion is not enough. For a cluster to be successful it must also tap the world market. It must, therefore, have a vision of how it will export its output, taking advantage of the innovation embedded in it. In the first instance this vision comes from the core or magnet firm. Being slow to articulate this aspect of the vision was costly for Lernaut and Hauspie, the core firm in Flanders Language Valley, as one of their sources of finance (GIMV) withdrew citing lack of export prospects. When the firm demonstrated those prospects, GIMV committed itself again. One should, even at the outset, consider the advantages and possibilities for non-core firms to take advantage of their innovative potential on the world market. Several case-studies mention export-training and information services provided by local institutions. (See for example the professional association AENTEC in the case of electronics in Madrid.)

When there is no obvious pre-existing core firm, a policy maker can either attempt to attract one from outside the region (see AutoEuropa), or to "grow" one locally (see FLV). Both options are difficult and risky. Support to incubators may create an innovative core firm but it is similar to waiting for an innovative break-through out of basic research. As with basic research timing is unpredictable, and one cannot be sure in which industry the technology may be relevant. Further, even with incubation support, policy may not be strong enough to keep the firm located within the region. However, the outcome of the incubation support is presumably more localised than the outcome when the magnet is a firm attracted from outside. A "home-grown" firm (and its technological vision and social norms) is likely to be more locally or regionally embedded.

Identification of a magnet is a first step, but other potential participants in the cluster must also be identified in the formative process. There also has to be some similarity, the firms must have something in common. We have called them "like firms". The "likeness" or "commonality" could arise from the fact the firms are all attracted by the same magnet. In FLV a core firm functioned as the magnet coaxing the agglomeration of like firms. The specificity of the core, magnet firm resulted in a specific group of attracted firms. In the cases of Taguspark and Sophia-Antipolis the magnet was initially not specific enough to create a "commonality". This clearly makes a difference in the operation of the cluster. There was a protracted period in Sophia-Antipolis and Taguspark before the firms found out what they had in common, besides location and the associated "hard" infrastructure in these parks. Based on the experience of these cases we can state that setting up a "softer" institution like an association could be necessary to reveal the commonality in order to transform agglomeration into a cluster. If the magnet is not specific enough, the identity of the cluster, the "cluster secrets", the social norms and the technological vision have to be the result of informal communication and interactions among potential cluster participants. Policy must foster, participate in, and take advantage of this type of interaction.

Human Capital. Each cluster is unique, but a typical bottleneck early in the life of a cluster involves human capital. This is true whether firms are migrating into a region to take advantage of spillovers of an innovative, magnet firm, or whether an existing agglomeration of firms (in existing supplier-demander relationships) wishes to change its relationships to generate innovation throughout the value chain. In both cases, transforming a region from "innovation deficit" to "innovative cluster" will involve investing in human capital. Locating in a region which suffered from a long manufacturing crisis, AutoEuropa wanted to avoid bringing in old local habits and routines , so it invested some 4 million training hours in labour market entrants and more than 850 workers were trained abroad.

When an innovation cluster forms out of an agglomeration of production (see for example the cases of Océ, Fiat in Piedmont, Flanders Drive and the Bologna Packaging District) a typical pattern is to upgrade existing human capital stock. Policy here must promote innovation within firms, and support education and training programmes within the industry. Public-private partnerships are likely to be the best organisational form.
On the other hand, some clusters form through the growth of a core firm and entry of others. In this case there is not typically a pre-existing labour force (in the industry) that can be upgraded. Migration becomes an important possibility, and policy makers have for centuries been involved in promoting their regions as attractive locales. Sophia-Antipolis, for instance, was built largely on its appeal as a place to live. Moreover, it seemed to have survived a crisis thanks to this attractiveness, since many people stayed after the firms they worked for left. The generic policy will be to provide attractive social amenities. Examples are cultural facilities (witness the success of the Birmingham Orchestra in making Birmingham much more desirable than it previously was); local services in the form of physical (roads, sports facilities) and non-physical (primary and secondary education) infrastructure.[21] But more actively facilitating migration, both permanent and short term, will reduce the costs of innovation for firms located there, and will thereby raise the profile of both the region and firms as loci of innovation and knowledge production. In-migration is not automatic but demands some infrastructure. Transportation and communication infrastructure are obviously important and must be developed. But in addition, infrastructure to support short and medium term stays (in the neighbourhood of several months) are necessary. The early history of the Flanders Language Valley involved a considerable period in which firms from outside the region sent personnel for periods of 3 to 6 months to work in the valley. This presented opportunities for valley firms, particularly Lernout & Hauspie, to absorb knowledge from abroad, and to demonstrate their own abilities as sources of advanced knowledge and technology. These sojourns were instrumental in the success of the Valley because of the importance of face-to-face contact for transferring tacit knowledge and know-how. Of course sojourns of this duration require more than the typical hotel infrastructure. The market is likely to provide it if it is sufficiently forward-looking, but might be assisted by projections by policy makers and by adaptation of local regulations such as zoning and planning regulations.

Local Protection. An innovation cluster is in some regards like an infant industry. Unless it is located in an entirely new industry, the cluster will face competition on the world market from existing firms (and possibly clusters) in the industry. A firm in an emerging cluster, because it does not have access to all of the advantages of those in an established cluster, is at a competitive disadvantage. Some degree of protection from or support in this competition may be desirable. Trade policy, particularly at the regional level, is not really an option, so protection becomes more like support. Provision of land for development of an industrial park (as in the cases of the Flanders Language Valley, Taguspark and Sophia Antipolis), for example, may be a way of reducing costs for the short run, while the cluster is being established. Similarly, there may be ways in which firms can be isolated from cost competition while they make transitions into the region or from being simple jobbing operations to innovating suppliers. This was the case for the KIC firms in the Océ case study. These and other forms of support may be desirable in the short run as the cluster is forming.

There is a second form of local protection which protects not the firms in the cluster but the cluster itself. As part of developing a young cluster, policies will be implemented to facilitate innovation. These policies must be designed to have two properties. First, they must benefit

[21] These examples are not exhaustive of the possibilities by any means, and indeed may not apply at all in some cases. They are merely meant to be illustrative.

only firms inside the cluster or geographical region. So policies must be designed with an exclusion formula built in. Second, they can be designed to encourage firms to migrate to the region. But here again, there must be selection — the firms must actively contribute to the health of the cluster. The experience of Sophia-Antipolis suggests that creating synergies is not simple, and that firms must complement each other in specific ways. As policy makers are unlikely to be experts in the technology at issue, it will be incumbent upon them to seek outside advice. The obvious source for this advice is from firms, and in particular the magnet or core firm, that exist in the region already. These firms have strong incentives to surround themselves with firms that are innovative and will create synergies with them, and thus are likely to give sound advice regarding potential recipients of regional protection or assistance. Involving incumbent firms in decision-making again creates both formal and informal interactions among firms and policy –makers that are vital to the success and coherence of any localised technological change.

Investment Co-ordination and Cluster Cohesion. In well-established markets, the price mechanism will co-ordinate investment. In a new, localised cluster, particularly if it is embedded in an industry experiencing rapid technical change, markets may not be able to provide the co-ordination needed to have efficient investment. The markets may simply not exist, or the information about how the technology will evolve may not be deep enough (there may be too few people with abilities to predict it) to support a well-functioning, thick market. Co-ordination must come from some other source then. Policy must aim here at providing either the mechanisms or the means to create the mechanisms for investment co-ordination. Some of the intervention comes simply from government making early investments in infrastructure of various kinds. This sends a signal and can act as a focussing device.
The second avenue is to organise the means by which a shared technological vision is created. In Taguspark, for example, informal meetings created a group of firms which share a vision on the future of the park itself and the benefits a "technology-park-effect" could offer them. In the Packaging Valley of Champagne several local "public" institutions provided the necessary internal co-ordination and cohesion. The Packaging Valley Association, for instance, has served to identify the firms in the region which are interested in co-operation, and to separate them from the firms in the region that have either too much or too little in common. In both examples we observe activities that are outside formal business transactions strictly defined.

Social "clubs" and professional and supplier associations facilitate informal interactions, create a cluster identity or image and help expectations to converge. These social institutions reveal to the cluster members what they have in common (and in what respect they differ). This social infrastructure may serve as a framework for collective action, like promotion, formal cooperation-projects and inducing other (locally) public goods. Existence of such organisations makes it easier for the policy maker to involve industrial members in decision-making, which will create a further level of cohesion, namely that between private and public activities in the cluster. More formally, seminars, workshops, fairs, exhibitions, which can be promoted by local policy, all contribute to the meeting of minds, exchanging of information and formation of a common vision. As this happens, better knowledge about the payoffs of potential investments will exist, and fewer bad investments will be made.

Local Promotion. The growth and future success of any innovative cluster will depend, in varying degrees, on the external perception that the region is dynamic and successful as a centre of innovation. Promotion of the region serves to raise its profile. It will also raise the profile of the firms and of the technologies they are developing. Both are valuable in terms of making the region a desirable place with regard to knowledge transfer. As clusters are created, there are various shortages or bottlenecks, particularly in terms of information or technology that must be overcome using external sources. For instance, if there is a core firm planning to out-source part of its innovation process, this has to be made known to potential suppliers so they can join the cluster. If the core firm cannot find potential cluster members in the region either they must be attracted from elsewhere, or local firms must be transformed into potential cluster candidates. (See the cases of AutoEuropa and Océ's KIC-cluster.) External sources are easier to locate and will be more enthusiastic if the firm or region has a good reputation. Part of a firm's reputation is created by the reputation of its location, so the region as well must be publicised as a good source of advanced knowledge. This is equally true with regard to attracting new firms to a region. It must be known as a good place to locate.

All of this is easier to co-ordinate if there is a coherent vision of the cluster. In the early days the cluster concept or vision is typically rather vague. Regional policy makers can see to it that the message gets articulated, a consensus is reached and diffused. They can (provide the communication infrastructure to) diffuse the cluster concept to agents in various local input and output markets (for labour, finance, training, real estate, supplies, etc.), which will serve to create the shared vision which can then be promoted outside the region. Once again this turns on there existing a coherent consensus regarding the nature of the cluster, which cannot be imposed from above but which must emerge from the agents directly involved, and their interactions.

National or European Policies

At a central level, there is less scope for policy intervention in the creation phase. The creation of clusters revolves largely around regions and regional initiatives, as regions are closer to the firms and are much more likely to be able to judge what infrastructure needs to be put in place for example. There are, however, three roles that a central policy maker, either at the national or continental level, can play.

Transition Funds. Regions that specialise in a particular industry will have problems when that industry begins to decline. This has happened in Wales, Wallonia and the Ruhr Valley for example. All were deeply entrenched in heavy industries that are no longer thriving in those regions. In this situation a region will attempt to change its specialisation to a new industry having significant growth potential. A declining region, however, may not have the financial resources to make the investments needed to support a new innovation cluster as it forms. The national or continental centre could create a fund on which such regions can draw to make the investments needed to change from one industry to another. The fund should operate on the principle not of direct, automatic grants, but rather on the principle of application. Regions would apply for funds with which to support a cluster that is just forming. The experience of Sophia-Antipolis and Taguspark indicate that attempts simply to buy a cluster with massive inflows of capital are both expensive and unlikely to succeed. Thus regions must present evidence of a magnet and an innovative core firm before the centre could intervene to provide assistance.

Co-ordination of Clustering Activities. As discussed above and in the appendix, there are many more regions in Europe than there are glamorous industries. Furthermore, European innovation clusters appear to be smaller than the critical size at which further growth creates negative rather than positive externalities. There is, thus, some risk of duplication and destructive competition among regions pursuing the policy of promoting clusters. Only a central policy is capable of alleviating this problem. This raises serious political problems, as intervention of this sort effectively involves deciding which region(s) will host particular clusters, which implicitly involves deciding which regions will not. Of course the centre does not have the power to prevent a region from trying to attract a cluster, but it does have the resources to assist one region in its attempts. In several countries there is some co-ordination on national level avoiding duplication. Since more and more the framework for regional policy and the science and technology policy stems from Brussels, co-ordination by the centre becomes even more appropriate.

The extent to which active intervention is necessary is difficult to state ex ante, but certainly, vigilance to the possibilities is necessary as innovation clusters start to form. At the initial stage of a cluster formation, the role of the centre will be essentially to provide information about other, potentially competing clusters that either already exist or are being formed. To make this effective and timely, a relatively passive policy of creating and publicising innovation maps of Europe would be valuable. To be useful in this context, these maps must be very specific as regards the industries in which innovation is taking place. Clusters should be readily visible and identifiable as belonging to specific industries.

There are also several more active ways that national and European policy makers can co-ordinate clustering activities. Involving researchers, captains of industries, policy makers and scientists in decisions about which (potential) cluster to assist may serve the ‘selection’ procedure, and help diffuse knowledge about clustering activity in distant regions. Inviting groups of agents to promote themselves as potential clusters may in itself have a cluster-inducing effect whether or not the applicants win this contest for public assistance. Promoting linkages between similar clusters in Europe and stimulating specialisation of the nodes in such a network of clusters could help to increase in general the number of clusters that can be supported while at the same time minimising the effects of the clusters being “too small”. (FLV for example is linked to other technological “districts” outside Europe.) The centre could for instance localise the nodes, or choose capitals in existing European networks created with technology programmes like Esprit. Finally, associations with a network mentality seem to be vital in many of the case studies. In order to assess what a cluster needs or may need in the future, policy makers must take part in these discussions. This is for instance recommended in the case of Taguspark.

Both politically and practically the only feasible moment at which to intervene is very early in the life of a cluster. Once heavy investments have been made at the regional level the centre is unlikely to be able to affect its development plans. If it acts quickly, however, the centre can forestall heavy investments in a cluster that would compete with an existing cluster. By having an explicit policy (and policy rule) of supporting only one cluster in any given industry, the centre can reduce the incentives for a regions to form competing clusters. This does not prevent two regions from starting competing clusters at more or less the same time, but if there are centrally controlled support mechanisms, when both regions apply to tap them, the centre is made aware of the potential competition and can mediate, or preferably, find a solution such that the planned clusters become complements rather than substitutes. Modern telecommunications technologies make the latter a feasible solution in many cases.

The discussions both of transition funds and of co-ordination suggest that the central policy maker must be able to exert some control. One approach is to have funds available to support localised technological change, but to have explicit minimum criteria which must be satisfied before application to access those funds can be made. The presence of a magnet, whether firm or technology; a coherent vision of the cluster; and projections of its integration with the rest of the innovation system could be demanded. If proposals to access support funds are developed over some period, in conjunction with the agency responsible for the funds, this will give an immediate policy entry into the issue of duplication.

Human Capital and Labour Mobility. While the specific human capital bottlenecks will be best known and thus best addressed at the local level, the centre can provide tools with which a region can address the issue. Migration of labour clearly involves more than one region and this permits a national or continental perspective on the problem. Particularly in cases in which the cluster is forming by transforming an industrial (production) agglomeration into an innovation cluster, SMEs often do not have employees with appropriate skills. Programmes to facilitate hiring "knowledge workers" serve two purposes. First, they may alleviate an immediate problem faced by an SME trying to upgrade its innovative capabilities. Second, and this is often more important, these programmes demonstrate the advantages of having highly skilled labour as part of the firms labour force, which surprisingly many SME are unaware of. Labour–mobility projects seem relevant here. Across Europe there are many schemes (e.g.: "Ice-breaker" in Denmark; "Knowledge carriers in SMEs" in the Netherlands; "FIRST" in Wallonia; "CIFRE" in France and the "Teaching Company Scheme" in the UK) which provide subsidies to SMEs in order to let them experience the value of hiring a highly-educated employee for innovative reasons. With these kinds of national tools, deployed at the local level, policy makers can develop a labour market segment necessary to serve a local innovation cluster.

Cluster Operation

Most of the policy implemented in the realm of localised technological change has to do with the operation of clusters of innovators. Policies put in place initially to aid cluster formation will, with some evolution, become policies that promote successful operation. The line between creation and operation is blurred, since part of a successful operation will include in-migration of new firms, which, of course, is to a large part what we think of as creation. The salient issues regarding the operation of an innovation district concern mainly the internal dynamics and dynamism of the cluster, factors which fuel the innovation process and factors which keep it localised. Once established, the attraction of new firms and new human capital and so on may no longer be a policy concern. Developing the infrastructure that keeps them and has them interact locally becomes the main concern.

Regional Policy

Infrastructure Development. Any successful innovation cluster rests heavily on communication of knowledge and information. This rests in turn on communication and transportation infrastructure. Given the public good nature of much infrastructure there is clearly a role for government here. It may be the case, however, that since the immediate beneficiaries of improved infrastructure are readily identifiable, public-private partnerships are possible as a way both to reduce public costs, and to increase the coherence between what is provided and what users think is necessary or desirable. Users know better than policy-makers what they need or desire, and will be better placed to make the trade-offs that are inevitable whenever there is a budget constraint.

There are, further, physical infrastructure needs. Transportation infrastructure is an obvious need, including especially links outside the region. These are necessary both for movement of goods, inputs and outputs, and for people. A successful cluster will be integrated with the rest of the world, and part of this integration involves both acquisition and diffusion of knowledge and skills. Effective communication now involves travel on a world scale. Conferences, collaborations and consultancies must be assumed to be international in scope, with concomitant implications for the kinds of transportation infrastructure needed.

More localised infrastructure development can assist in sustaining social and business norms. It is difficult to imagine a policy maker being able to dictate a social or business norm. What policy must aim to do, it seems, is to facilitate the process by which any social group comes to consensus. Again, creation of opportunities for agents to interact with each other will foster the sort of trust needed to form a cluster built on formal and informal networking. Ensuring that there are sufficient attractive public meeting places, creating the sorts of formal industry meetings, and promoting discussion of the importance of certain types of behaviour can all be roles for policy.

External Linkages. Throughout the life of any cluster, linkages with the outside world will be important. International communication remains important, though the role it plays changes over the life of the cluster. But undeniably as the cluster grows, the amount of communication will increase. This must be anticipated, and the infrastructure developed ahead of demand. The core firm in the Flanders Language Valley (Lernout & Hauspie) for example, found it necessary to engage in an "expert exchange" with a firm (later to become its subsidiary) in the US. This firm had technological knowledge that was central to the development of the L&H technology.

Two policies are obvious. The first is to ensure that the telecommunication and transportation infrastructures are well-developed. This makes it relatively easy for agents within the region to contact those outside. The second, and less obvious, is to make it attractive for people from outside the region to come to the region for relatively extended periods of time. This sojourning creates a good ground for trust-building interactions and for informal transmission of knowledge. As the Flanders Language Valley was starting to grow, many firms from outside the region sent employees to Ieper for periods of several months. This is a very effective way to transfer tacit knowledge among different agents, and to tap the resources not available in the region. The presence of short term accommodation, which may be affected by zoning by-laws is obviously crucial to making this kind of visit possible.

When a firm is interested in basic research, it tends naturally to create links to whichever university is best at that research, whether it is local or not. When the firm is interested in applied research, however, it looks to local universities. (See Mansfield, 1995.) A firm located in a region not having a university is clearly at a disadvantage. Policy must intervene to try to overcome that disadvantage. Various forms of infrastructure for interactions with agents outside the cluster are important. As evidenced in the case-studies, several kinds of institutions like technology centres or associations seem to be able to overcome this disadvantage, playing an intermediary role between the cluster and R&D centres outside the cluster. These intermediary technical institutions are especially important for the SME population in the clusters, as large firms tend to have direct links to universities both local and distant.

In more mature clusters we see a change towards a more "outward looking" behaviour of the cluster members. Several of the case studies show such a change in operation. No longer do only the core firms have innovative linkages to the outside, but fringe firms do as well. (See for example the cases of Bologna's Packaging District and Fiat's automotive technology district in Piedmont.) Most notably the first ring or layer of suppliers around the core tends to look outside the region. Restructuring intermediate input-output linkages is clearly co-ordinated by the core firm. However there may be a policy role in providing support to the fringe. Many small firms have to adjust and several have to look for linkages outside the cluster in order to import or export new knowledge. Regional policy makers can provide the proper institutions and infrastructure. They can for instance organise export training, platforms, foreign trade trips. Technology centres may screen for the latest technology developed outside the cluster. We have read in several case studies that the core firm often loses its monopoly on the external (outside the cluster) input and output linkages. Regional support may help to link others to outside markets in order to exploit the cluster and get a local return on the early public investments.

Financial Development. Venture capital is a perennial issue in Europe. The Flanders Language Valley Fund provides an exemplary solution which links the problems of start-up financing to cluster creation and operation. The FLV Fund is a public-private venture, with most of the private capital generated locally. Applicants to this fund are vetted by firms that already exist in the region. Thus decision-making about applicant firms based on new technologies has first-class technical expertise. This expertise will be highly aware of how a new firm will fit into the business and technological landscape of the cluster. But equally important, it means that existing firms are very knowledgeable about what new firms are trying to do, and about the technologies that are being developed. The operation of the fund is a venue at which individuals meet each other, and can serve to introduce the kinds of informal, social interactions that can be so vital. Reading and hearing business plans of applicants to the fund is an opportunity to learn about the newest ideas. Discussing these plans creates consensus among existing firms about how both the technology and the market will develop, an activity that is vital in creating the kind of technological shared vision that is so important in a fast-moving industry.

Business Services. One of the features present in successful innovation clusters is specialised business services. These include *inter alia* research, marketing, finance, testing and legal services. In the Tanning District of Alcanena specialised environmental services have become important. In the automotive district in Piedmont specialised services in design have become important, and not only for Fiat. The Fiat Research Centre has become independent and started to provide services to local SMEs as well. The provision of these services can be affected by considerations of increasing returns to scale. For example, a testing laboratory can support more than one client. But in the early life of a cluster, there may be only one potential client. No entrepreneur will open a testing laboratory to serve one client. The client, then, in the absence of a local testing laboratory, must go further afield to get his testing done. The absence of testing facilities will make this location relatively unattractive to potential entrants, and potential clients of such a facility. The aim of policy is to facilitate creation of these services, which can be done with fiscal incentives, or joint investments. It can provide incentives to create such specialised services as part of an incubation approach. Again, public-private partnerships may be the appropriate vehicle here, since there are serious start-up problems but the (private firm) beneficiaries can be readily identified. Business plans of potential entrants to the cluster can be a source of valuable information regarding which services will be most important to the success of the cluster.

Human Capital Development. Little more need be said about human capital development. Any innovative activity demands human capital, and a cluster will, eventually, have to be able to generate at least some of that capital endogenously. Policy makers must ensure that the education and training facilities exist to provide this service. While it is common for a cluster to hire labour from outside, a total absence of ability to generate it within can be detrimental. Local labour tends to be less footloose than imported labour, so a relatively high proportion of "home-grown-talent" can positively affect the stability of the cluster. Training institutions also seem important to enhance the localised character of knowledge and learning. The technical school founded by local government in the Packaging District of Bologna is a good example.

National or European Policies

Labour Mobility. By definition, a successful, thriving cluster will be eternally in flux. As it develops products and technologies, not only its outputs but also its inputs will change. Particularly as technologies change, different types of human capital will become more and less important. While over the medium or long run it is possible to make these changes from within by re-training, in the short run this is often not possible. Labour migration becomes vital to keep the dynamism of a cluster.

International labour mobility continues to be an issue in Europe, and until solutions to such things as the portability of social insurance are found, it will continue to be so. A market that is monolithic in this regard and as regards language, (for example the US) will always have an advantage over one that is not. Support of international exchanges, partly aimed at improving participants' language skills is a long-term strategy that would facilitate future labour mobility. Creating a European, transportable pension and unemployment insurance funds would also improve labour mobility.

Identification and Support of Success. Locally learned lessons must be recognised and diffused. Before national and European policy makers can co-ordinate the increasing number of growing clusters there is need for identification and evaluation of the success or failures of the regional initiatives. Regarding the creation of clusters the centre has to map the potential and the initiatives taken at the regional level. Regarding the operation phase the centre has to map the growth and identify success and failure. Benchmarking the growth and operation in clusters may help to draw conclusions regarding the relevance of co-ordination and intervention. Benchmarking policy tools may be a way to see to it that lessons in designing and implementing policy are learned.

The close involvement of the regional policy makers in a cluster may induce a resistance to exit the initiative and leave the development trajectory they have chosen to support. From a greater distance, with a broader view and reasoning at a larger scale and scope regarding public policy, the centre may provide the arguments to withdraw or intensify intervention.

The success of a cluster may have become too big for one regional administration. Anticipating an exploitation potential at national or European level, may call for additional National or European support.

External Linkages. The literature on National Systems of Innovation indicates that to be successful an innovation system must "have it all". That is, there are many inputs to the innovation process and success depends on all of them. It is easily conceivable that a nation could have all of these components well-developed. But it is also easy to imagine that many regions do not — many regions will lack some part of them. In this case, the goal of policy must be to compensate for this lack. One obvious tack is to create strong external links.

Above we discussed one role that university-industry links will play. Promoting firm-university links with universities outside the region plays another role. Universities act as buffer institutions between firms. Two firms competing in the same industry may be wary of direct links with each other for fear of losing trade secrets. This can mean that potentially valuable information diffusion is lost. Firm-university links pose much less of a threat in this regard.

Further, knowledge diffuses relatively freely within the university (more generally non-profit research) community, and tends to diffuse as scientific or technological knowledge rather than as knowledge that has direct or obvious market implications. Thus firms can interact with the university system, contributing and acquiring knowledge and information. Actively promoting this can mitigate some of the diffusion problems created by fears of secrecy.

Links external to a region will obviously involve more policy than is possible at the regional level. Thus these external activities will inevitably be subject to some central policy measures. In part the role of the centre will be to co-ordinate. But it will also be able to provide infrastructure investment, and direct financial incentives for collaborative research that involves more than one region and more than one type of institution (industry-university collaborations for example). External links are also an important aspect of cluster exploitation, to which we turn now.

<u>Cluster Exploitation</u>

As discussed above, exploitation is almost by definition a policy issue for the centre — for national or continental policy makers. The goal here is to leverage the cluster to improve wealth creation beyond its borders, and, following the National Systems of Innovation literature, distribution and diffusion of knowledge is the key (David and Foray, 1995).

Regional Policy

Reduce protection and address congestion. As stated above the idea of permanent policy support has to be abandonned. This is particularly true when we acknowledge that too much clustering is not healthy. Relentless agglomeration and accumulation may create negative agglomeration effects and congestion. We may think of congested communication and transportation infrastructure, but also on local input markets. If promotion of agglomeration within a region continues to be too successful, for instance, excessive price competition on local real estate market is an real threat. Once a cluster is created and operating, the protection therefore must be reduced. The cluster may have already become too big for one regional administration, or spilled into a neighbouring region, even though it may not have reached its critical mass. If this is the case, co-operation with neighbouring regions becomes essential. There are several other options to address local congestion. Regional policymakers could look for new potential clustering in other industries or support new but complementary niches.

National or European Policies

European Clusters. European policymakers may want to identify the most successful clusters in Europe and exploit them in a global competition, where Europe competes with other continents. Identified by the suggested cluster policy system, European policymakers are able to select these "winners" and label them European. The centre may take over the role of the regional policy makers in supporting these first European clusters in order to exploit them for the sake of the European level.

External networking. Exploiting a cluster involves leveraging its success into wealth creation for the economy beyond its spatial extent. To the extent that this is amenable to manipulation by policy, the policy will be national or continental. It is obvious that the key to exploiting a cluster is extending the diffusion of the knowledge it generates (here 'knowledge' should be read very broadly, to include not only knowledge per se but also knowledge embedded in new products and processes or technologies). In this regard, it is possible for a cluster to be too tightly internally connected. Clusters work effectively if there are close connections among the agents within a cluster, with many local interactions. It seems desirable that agglomerations be tightly linked internally. This creates an effective diffusion network. But from the global point of view a cluster can be too tightly internally connected. This follows from a constraint — it is reasonable to assume that any agent working in the knowledge sector will devote only a certain amount of his time and energy to interacting (formally and informally) with other agents. If those interactions are local, they are not with people in distant parts of the economy — one cannot be in two places at once. Thus activities or network structures that foster excellent local diffusion can impede global diffusion. (See the case of vehicle component manufacturers in Spain: "Less proactive companies in our analysis however, risk over-reliance on tacit knowledge resulting from [local, Spanish] historical experience.") If we consider the entire national or continental innovation system as a network around which knowledge is diffused (of course this captures only one part of the system) we can employ some recent theoretical results to indicate the sort of goal that a central policy maker will have in this regard. From the point of view of the centre, the goal is to increase European income. Assuming that increases in income derive from innovation, then increasing global knowledge levels is key. Recent work on network structures suggests that for effective diffusion of knowledge, between 5 and 10 percent of the links within the network of knowledge workers should be non-local. That is, roughly 5 to 10 percent of the time an agent spends interacting with others should be spent interacting with agents outside his geographic cluster.[22] (See Watts and Strogatz, 1998; or Cowan and Jonard 1999.)

For instance in the case of the Spanish broadcast industry we may emphasize the role of the producers' federation (FAPAE) and the state agency for audio-visual Arts (ICAA) which promotes international co-production agreements in order to enhance export of Spanish films. In the case of the electronics industry in Madrid we have seen that the export commission of the professional association AENTEC (which can be traced back to the initial idea of the Spanish Public Administration) is the most active working group. Other workgroups are devoted to R&D, finance and training.

Labour Mobility. One form of networking involves the movement of personnel among firms and other institutions. Particularly important, given the insights of the "coupling model" of innovation, is movement of personnel among different aspects or parts of the system. For example, movement between firms and universities creates knowledge transfer between basic and applied research or development. Similarly transfers between firms at different points in the value chain will strengthen user-provider links and knowledge transfers. One way in which the centre can contribute here is to make this sort of exchange part of the criteria for judging bids for research funds.

Movement of personnel within an existing cluster is not difficult from the administrative point of view, but attracting new people to a cluster may be difficult if those people originate in a different country. This is an issue with which Europe has yet to deal, namely the transferability of things such as social insurance, pensions, and so on.

[22] That each agent spend 5-10% of his time interacting non-locally is not necessary of course. The long range interactions could be the activities of agents who specialise in them, spending far more than 5-10% of their time in these long range interactions. Under such a structure tight links between the 'long-range specialists' and the rest of the agents in the cluster will be crucial.

Conclusion

A coherent policy for localised technological change must be a policy system. It will consist of regional, national and continental frameworks in which interdependent and internally flexible innovation policy schemes induce private as well as public learning through public-private interaction. Both in designing the intervention mechanisms and in delivering the support policy makers must be aware of their changing relevance throughout the policy process. Policy goals and targets change during the transformation processes towards a system of innovative, learning firms and regions. The concept of localised technological change suggests that innovation policy addressed to the local and regional level should be customised to meet the specific conditions of each case. To orchestrate localised learning in clusters, policy makers need to do more than communicate through price or authority. To support innovative clusters as the meso-level between firms and the region, policy makers will have to take part in the localised discussions in order to communicate the tacit dimensions of innovative clustering. An interactive mode of intervention seems more appropriate than a linear one in assessing what the cluster and its firms need and have to offer and in delivering the actual support.

5. DISSEMINATION AND EXPLOITATION OF RESULTS

Dissemination has been organized at two levels. Dissemination to a Policy/Industry Audience and Dissemination to an Academic Audience. The details of the main events follow in sections 1 and 2. Exploitation is mainly based upon publication: details are provided in section 3.

1. Dissemination to a Policy/Industry Audience:

1) ESRC /IMI conference, Learning Across Business Sectors, University of Warwick, UK, September 1998

2) Briefing to UK Minister for Science (Lord Sainsbury) on our Cluster Research, DTI, London, February 1999

3) Economic Adviser to CBI (Confederation of British Industry) Working Party on "Clusters", August-October 1999

4) Introductory Presentation to DTI seminar on "Clusters", chaired by the UK Minister for Science, Westminster, September 1999

5) Participation in Cabinet Office Project on "Future Sources of Competitive Advantage", UK Cabinet Office, Whitehall, October 1999

6) Member of one of the six Competitiveness Working Parties set up by the President of the Board of Trade, to make inputs to the 1998 Competitiveness White Paper - in which clustering featured prominently (early 1998)

7) Meeting of the Confindutria Scientific Committee on 'Technological districts and th eproduction of knowledge', Rome, May, 1999

8) Presentation at the Board of CoRiPe (Consorzio Ricerca Piemonte) of the results, Torino, December 1999

9) Meeting of the ENEA Scientific Board on 'Regional clusters and innovation', Rome January 2000 (planned)

10) Participation in Seminars with local authorities (SAEM-Sophia-Antipolis) or associations involved in local development (Association Packaging Valley)

11) Use of the projectís results and learning in relevant national audiences (Association France-Technopoles, French Délégation à l'Amànagement du Territoire et à l'Action Règionale, Commissariat Gènèral au Plan, Centre National de la Recherche Scientifique)

12) Participation in different seminars organised by Region Provence-Alpes Còte d'Azur for the elaboration of the ´Contrat de Plan Etat-RÈgion†ª

13) IWT Cluster Seminar (Belgian institute for Science and Technology) on Cluster Policy Lessons from Flanders, the Netherlands and Austria. Gent, Belgium, April 1999.

14) MERIT/Capio Consult Workshop "Monitoring & Evaluation of Regional Technology and Innovation Policy, attended by Dutch, regional and national policymakers and intermediary organisations. Eerbeek, The Netherlands, June 1999.

15) Bilateral briefing of INLOCO results to key actors in the clusters studied by MERIT, 1999.

16) Discussion of the results of MERIT's case studies and was asked for advice in several meetings with the Province of Limburg (NL) and other participants of the Regional Technology Plan Limburg. Geleen, The Netherlands, November 1999.

16) Interview-meeting with the industrial associations involved in the three Spanish cases (audiovisual, electronic, car industry): FAPAE, AENTEC, ANIEL, ANFAC, etc.

17) Presentation at the Regional Forum of Madrid of Liason Offices from Public research centres and universities and responsibles of Regional Plan of R&D. Organized by the University Carlos III (3/12/99).

18) General dissemination on the university-regional industry forum, organised by the UC3M, January 2000.

19) General presentation on a meeting with the responsables of the S&T policies of the regions of Madrid, Catalonia, Vasc Country, Galicia, and Andalucia, organized by the CSIC-IESA. Planned for January 2000.

2. Dissemination to an Academic Audience

1) EARIE, Torino, September 1999 (Beaudry,Cook, Pandit, Swann)

2) Conference on Les Strategies des Entreprises Multinationales, Sorbonne, Paris (Beaudry)

3) CRENOS Conference, Technological Externalities and Spatial Interaction, Cagliari (Breschi)

4) Beaudry has given a seminar presentation to PREST, University of Manchester.

5) Cook has given seminar presentations at the Universities of Manchester, Loughborough and UMIST.

4) Swann has given a seminar presentation at City University, London.

7) Antonelli has contributed the paper 'Territorio come produttore di conoscenza' at the Conference 'Il mondo e i luoghi: geografia delle identitià e del cambiamento, Torino 15.10.199

8) Antonelli has contributed the paper 'Torino: Il territorio la città e l'industria' at the Convegno Internazionale di Studi, Tiorino 21-23.11.1999

9) “Flanders Language Valley: Industrial Districts and Localized Technological Change” published as Merit Working Paper # 99-032.

10) “Knowledge Intensive Industrial Clustering around Océ: Embedding a vertical disintegrating codification process into the Eindhoven-Venlo region” published as Merit Working Paper # 99-033.

11) P. Swann "Key Issues in Measuring Clusters", Presentation to DTI Seminar on Clusters, Chaired by Minister for Science, London, September 1999

12) C. Beaudry "Clusters, Growth and the Age of Firms: A Study of Seven European Countries" European Association for Research in Industrial Economics (EARIE), Turin, September 1999

13) N. Pandit and G. Cook "The Dynamics of Industrial Clustering in UK Financial Services", European Association for Research in Industrial Economics (EARIE), Turin, September 1999

14) P. Swann "Clusters", Presentation to DTI/ESRC Seminar, DTI Conference

15) P. Swann 'Networks and Clusters', presentation to ESRC /IMI conference, Learning Across Business Sectors, University of Warwick, (23rd September 1998)

16) P. Swann 'The Dynamics of Industrial Clusters', seminar at City University, London (May 1998)

3. Exploitation

The following publications have been already submitted and/or accepted:

1) Antonelli, Cristiano, *The microeconomics of technological systems.*. (Monograph)

2) Antonelli, Cristiano (editor), *Technological districts: communication and innovation.* (Edited book collecting 8 case studies)

3) Antonelli, Cristiano, Collective knowledge communication and innovation: the evidence of technological districts. *Regional Studies*, forthcoming

4) Antonelli, Cristiano, Restructuring and innovation in long term regional change, in Clark G.L., Feldman M. and Gertler M.S. (eds.) *The Oxford Handbook of Economic Geography*, Oxford: Oxford University Press.

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