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Alain Alcouffe

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National Innovation Systems and Industry Science Relationships in Europe

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Abstract

Globalisation means radical changes in foreign affairs and consequently in tariffs. Domestic markets are no longer sanctuaries for big firms which are more and more multinational in their ownership, governance, scope and aims.

All these evolutions challenge the relevance of the "national" innovation system concept whereas American authors doubt if the American innovation system will be able to maintain its high level of performance as all of the central components of the innovation system now are undergoing change.

Structural changes in the national systems of innovation system, are not occurring in isolation and may well result in some "convergence" in structure which would imply that the raison d'être of the NIS analysis could disappear. The European integration sets up another challenge to the NIS analysis. What will come out from the old national innovation systems whereas there are currently three institutional settings to take into account to deal with industry science relationship?

After reviewing some threats against the NIS, the paper shows that a great deal of globalisation is actually Europeanisation even if the European law framework is still very sketchy and analyses the possible emerging European innovation system. It insists on the increasing human capital mobility in high tech sectors and supply some evidence of an emerging European innovation systems. The small country case is also analysed with its variants as it appears when looking at Portugal and Austria. Simultaneously if the project driven ISR seems obsolete, innovation policies will more and more relying on the financing of basic research as well as on local, national, and European infrastructure. In the European case, it seems also important to improve the links between the higher education system and the SMEs.

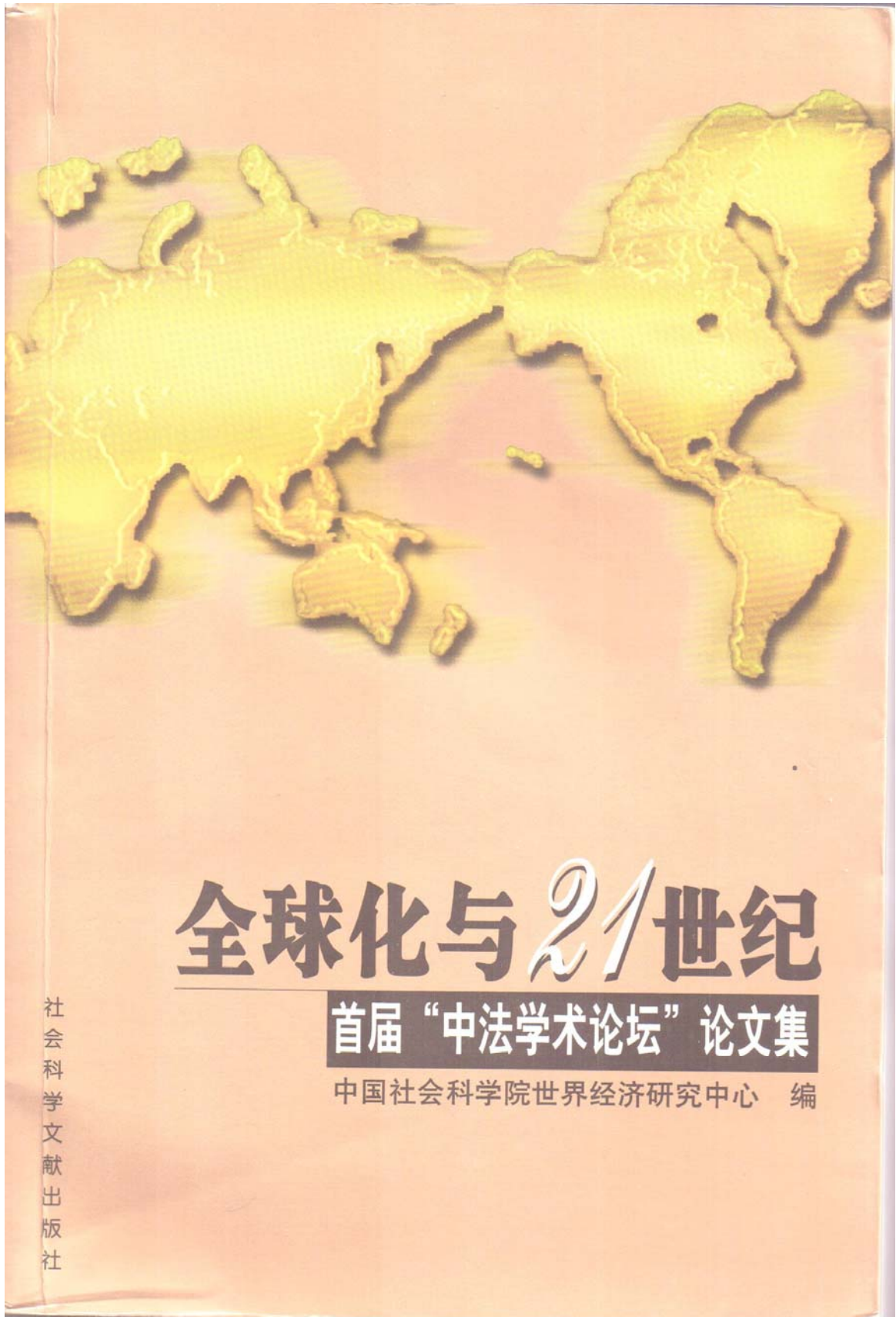
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(draft version : comments welcome)

The ‘National System of Innovation’ or ‘National Innovation System’ concept was coined at the very beginning of the 90’ by C. Freeman, B. Lundvall and represents probably a case of multiple discovery as hints are to be found in the 80’ by several authors (Maurice & Silvestre)¹. It can be define as a network of institutions operating in the public and private sectors whose activities and interactions introduce, modify and diffuse the new technologies. This approach stresses the specificity of the choices that shape the various national systems, in particular through public policies on education, academic research, legislation on patents and intellectual property and access to finance for emerging technologies.

The result is a certain dynamic irreversibility contained within “particular institutional infrastructures” (see Nelson, 1993). Firms draw on the institutional resources of their countries of origin in order to construct their competitiveness and, more generally, to operate effectively in globalised markets. The interaction between firms and these institutions gives them access to more or less effective organisational and technological learning processes through which national industries acquire their particular configuration (Lundvall 1988).

In order to take a more operational approach, it is convenient to distinguish inside a country three fields more or less tightly related to the innovation process : training and education, research and production and stresses the importance of the flows which circulated between the summit of this triangle. These flows are manifold and include very different items : money, men, training, products, know how, knowledge. In the NIS definition, the assumed interdependence of these three fields justifies to speak of “ system ”. The innovation system is further called “ national ” because it is asserted that for the intertwining of the three fields, national history, national features (etc.) matter. By some authors, the national character implies too that the bulk of the domestic flows which irrigate the different fields is “ national ”, due to the limitation of human capital mobility, to the links between defense (i.e national) R&D and civilian R&D in some countries, more generally to the special part played by R&D in business and national strategies, etc.

"It is somewhat paradoxical that a concept relating performances to national features was elaborated and devoted much attention in the 90’ while many observers stress the importance of “ globalization ”. In direct connection with our topic, we can excerpt the following notes in the introduction of a OECD 1999 report : "The increasing pace of globalisation can be observed in the heightened importance of patenting by firms abroad;

* This paper tries to synthesise many firm or sector monographs which were circulated in the SESI project between 1998 and 2001. Stylized facts and examples which sustain the argument are directly drawn from these essays. The author thanks his partners in the SESI Networks especially Luisa Oliveira, Hirohatsu Nohara, Eric Verdier, Alice Lam, Saloua Bennaghmouch, Martin Unger and Kurt Mayer. He is responsible for the opinion expressed in the paper and, of course for any mistake or errors.

¹ -cf Archibugi, et alii. "The 'system of innovation approach has developed and evolved since its initial appearance in the form of the national systems of innovation. (NSI) studies presented by Freeman, Lundvall and Nelson. Chris Freeman was among the first to use the concept to help describe and interpret the performance of Japan over the post-war period. He identified a number of vital and distinctive elements in its national system of innovation to which could be attributed its success in terms of innovation and economic growth. It has subsequently been applied to a number of different contexts, many of which has been outside the original focus of a national setting. Then, although the national focus remains strong and rightly so, it has been accompanied by studies seeking to analyse the notion of systems of innovation at an international (or pan-national) level and at a sub-national scale."

increases in the relative importance of both inward and outward research-related foreign direct investment; the explosion of international strategic alliances in science and technology; and increasing trade in technology." *The Letter of OST 2000* "The world economy is increasingly based on cross-border transfers of information and knowledge and the field of innovation can be considered as one of the best cases of globalisation"

Globalisation means radical changes in foreign affairs and consequently in tariffs. Domestic markets are no longer sanctuaries for big firms which are more and more multinational in their ownership, governance, scope and aims. Globalisation means too that corporate governance could no longer be protected by a secrecy wall and managers have to convince financial markets that they are "good". Consequently as nobody can believe that a firm can be efficient in many industries, conglomerates are no longer efficient way to follow and firms try to specialize and concentrate on their core competences. The same is true for states which could no longer follow the technical progress in all sectors even for large countries as the USA (see Crow and Bozeman). Moreover suspicion against the ability of governments to interfere with businesses strategies has grown and R&D public budgets are cut in many countries.

All these evolutions challenge the relevance of the "national" innovation system concept whereas American authors doubt if the American innovation system will be able to maintain its high level of performance. Mowery argues that virtually all of the central components of the innovation system that emerged in the postwar U.S. economy now are undergoing change. He The future U.S. innovation system is likely to be characterized by

- lower levels of overall federal R&D funding.
- lower levels of defense-related R&D funding and procurement activity.
- reduced military-civilian technological spillovers.
- a higher level of internationalization, both in terms of U.S. R&D investment in foreign economies and in terms of higher levels of non-U.S. R&D investment within the domestic U.S. economy.
- more stringent domestic and international protection of intellectual property rights.
- Less stringent domestic antitrust policy.
- higher levels of interfirm collaboration, university-industry collaboration, and collaboration between U.S. and foreign firms in R&D.
- greater efforts by U.S. universities to seek to protect and license the results of publicly and privately funded research.

The implications of these changes for the performance of the U.S. innovation system, and for the role of this system within the global science and technology system, are unclear. The effects of some of these changes, such as the efforts by U.S. universities to protect and market the results of their research, may be modest, because of the lower quality of much of these recent patents. In addition, the sporadic efforts by federal policymakers to limit the international dissemination of the results of publicly funded basic research and technology development programs have in many cases been frustrated by the ineffectiveness of these restrictions and by the actions of private firms in the United States and other industrial economies. But other structural changes, especially those affecting defence-related procurement, the role of universities, and intellectual property rights and antitrust policies, could reduce the importance of new firms in the commercialisation of new technologies and in the creation of new industries. The effects of these changes are mediated and possibly offset, however, by the abundance of venture capital for the foundation of new technology-intensive firms within the United States, as well as the relatively modest entry barriers in segments of such rapidly growing "new industries" as computer software and multimedia.

Structural change in the U.S. innovation system, of course, is not occurring in isolation from change in the structure of other industrial economies' innovation systems. Indeed, one of the defining characteristics of such structural change in the United States is increased links with non-U.S. firms and government-supported programs. Structural change in the U.S. and foreign nations' innovation systems nevertheless may well result in some "convergence" in structure.

Systems of innovation and social systems of innovation and production

Some authors have tried to enlarge the NIS approach which is for them too restricted to science and technology matters and refer to social systems of innovation and production (SSIP). By the way, they come very close to compare varieties of capitalism. Amable, Barré & Boyer 1997 distinguished four such SSIP: Firstly, one, market driven or "*Anglo-Saxon*", is exemplified by the USA, Australia, Canada, and in Europe by the UK. The second one, social democratic, encompasses the Scandinavian countries. The third one, *mesocorporatist* has an unique example, Japan. Features of the last one, "*European integration*" are to be found in Germany, France, Italy and the Netherlands. But even if SSIP are conceived more as ideal types than as categories of concrete national economies, a historical analysis of growth trajectories leads to a ranking of performances and authors cannot escape to benchmark these varieties. This approach rises then the question of a possible convergence towards the more efficient model of capitalism which appears to many observers to be the Anglo-Saxon one in the 1990's (Goyer 2001, Paillard & Amable 2000). Applying econometric models to a database including several variables referring to economic but also technological and scientific performances, Amable and Petit have compared 21 countries in the in the 1990's. They concluded that results from the more recent data do not differ strongly from those obtained for the 1980's by Amable, Barré, and Boyer (1997). They found that Norway has moved from the social democratic SSIP to the market driven one whereas Korea has now joined Japan in the *mesocorporatist* SSIP. As far as the European Integration model is concerned, they augment it with two variants. To the countries included in the European SSIP in 1997, they join now, Belgium and Ireland whereas they include Italy in a Mediterranean variant with Spain, Greece and Portugal. Moreover they distinguish an "*Alpine*" variant formed by Austria and Switzerland.

Despite some interesting insights provided by this very large approach, the multiplication of variants recalls us that enlarging the scope is no guarantee for a better understanding, therefore we will focus on the systems of higher education and innovation.

The threats of globalisation on NIS

As formulated by D. Mowery, this convergence implies that the *raison d'être* of the NIS analysis could disappear. This theme has been addressed to by Jean Guinet in his report for OECD on Industry Science Relationships.. He remarks that ISRs have been structured around national research organisations and domestic firms at a time when the strategic interests of the different stakeholders converged easily towards national goals. Their international linkages were mainly through the scientific community that has a longstanding tradition of global networking. The situation has evolved gradually during the 1970s and 1980s with the intensification of government-sponsored international co-operation in technological development, especially within Europe. The globalisation of firms' R&D strategy and access to public research together with increased mobility of scarce highly qualified labour now lead to much more fundamental transformations:

Global Trends in Industry Science Relationships

- The hierarchical and centralised model of ISRs governance that still prevails in a majority of countries must leave way to a contractual and decentralised one. Within public/private partnerships the source of initiatives is shifting from government to firms, within governments from central to regional and local authorities, within public research from public labs to universities, and within public research organisations from central management to labs and research teams. Now that mission-oriented public research can no longer play a pivotal role within ISRs, new market-friendly co-ordination must be implemented, with greater involvement of the financial sector, especially venture capital.
- *Foreign firms makes often more intensive use of public research than domestic ones* and the efficiency of national support measures is enhanced when recipients are parts of dynamic international networks. Government must rethink how to maximise national benefits from ISRs that involve industrial participants taking a more global perspective. Building on globalisation to increase national benefits may require easier foreign access to national programmes and the relaxation of eligibility criteria regarding the location of publicly-funded research activities, as well as greater international co-operation among governments to avoid opportunistic behaviours and distortions of competition.

Globalisation prompts public funded organisations to reconsider their role in the economy. Some now enters into broad alliances with homologues or private firms in order to create knowledge platforms, which could become key infrastructures of the “new economy”.

The dynamics of evolution in ISR

But the pace of this evolution cannot be very rapid as the innovation system as the NIS analysis has repeatedly shows exhibits many path-dependencies. Chemical played a dominating rôle in the process of industrialization in Germany. The foundation for this can be found in the 19th century. Many of the German Competitive positions were created by the turn of the century, when Germany was characterized by a close connection between universities, Technischen Hochschulen and industrial firms. With the universities and Technischen Hochschulen, Germany has established a sophisticated system for education in scientific, technical and commercial matters, reaching from elementary schools to doctoral level. This system has had a significant influence on the structure of the German system as we know it today. And I. Drejer shows that the roots of German strong positions in chemicals are to be found in the beet-sugar industry of the late 19th century. (I. Drejer, p.383)

Consequently, Jean Guinet notes that if globalisation and the diffusion of best practice policies reduce differences between national systems of ISRs and may change their comparative advantages but cannot abolish the considerable diversity of existing models². The interactions between the public research sector and industry take various institutional forms and differ in nature and intensity by country reflecting national specificities in institutional set-ups, regulatory frameworks, research financing, intellectual property rights and in the

² In the same sense see D Archibugi : "first, globalisation makes easier the transmission of best-techniques across countries. Semiconductors, antibiotics and new materials are based upon similar and shared knowledge across the globe." Of course, this does not imply an automatic process of acquisition of knowledge since learning is neither instant nor automatic. The tenants of the globalisation thesis themselves introduce a caveat : "While these general trends touch all OECD members, they present different challenges for individual countries -depending mostly on their industrial structure, the size and openness of their economy and the strength of their science and technology base. In fact, the globalisation process has not markedly diminished differences in innovation systems and may be accentuating the technological specialisation of firms in different regions.". This general stability does not prevent rather quick reversal as the ones experienced by the US semiconductor industry during the last decades. The decay during the 80's has been followed by a quick recovery in the 90's (see, Macher; Mowery; Hodges 1998)

status and mobility of researchers. Existing internationally comparable indicators capture some of these differences. Measurable national differences with implications for industry-science linkages include variations in: *i*) which institutions perform and which fund research development *ii*) trends driving the funding and performance patterns of R&D; and *iii*) specialisation in specific scientific disciplines.

Jean Guinet shows an extremely large dispersion of the rates of government funding. Following the OECD classification, the share of government in funding and performance can vary from low to very high through five steps whereas the system can be based on universities or institutes or combine the two institutions. Among the countries under review in the Sesi project, Portugal belongs to the countries with a very high share of government in funding and performance. Austria and France to the countries with a moderately high share of government in funding and performance, the United Kingdom and Germany to the countries with an average share of government in funding and performance; the United States to the countries with a low share of government in funding and performance. The dispersion is almost equally important if we consider the three subcategories concerning the constellation of actors in the ISR : Austria, the United Kingdom, and the United States fall in the university based system, France, Germany, and Portugal in the broad-based system.

National innovation system and country size

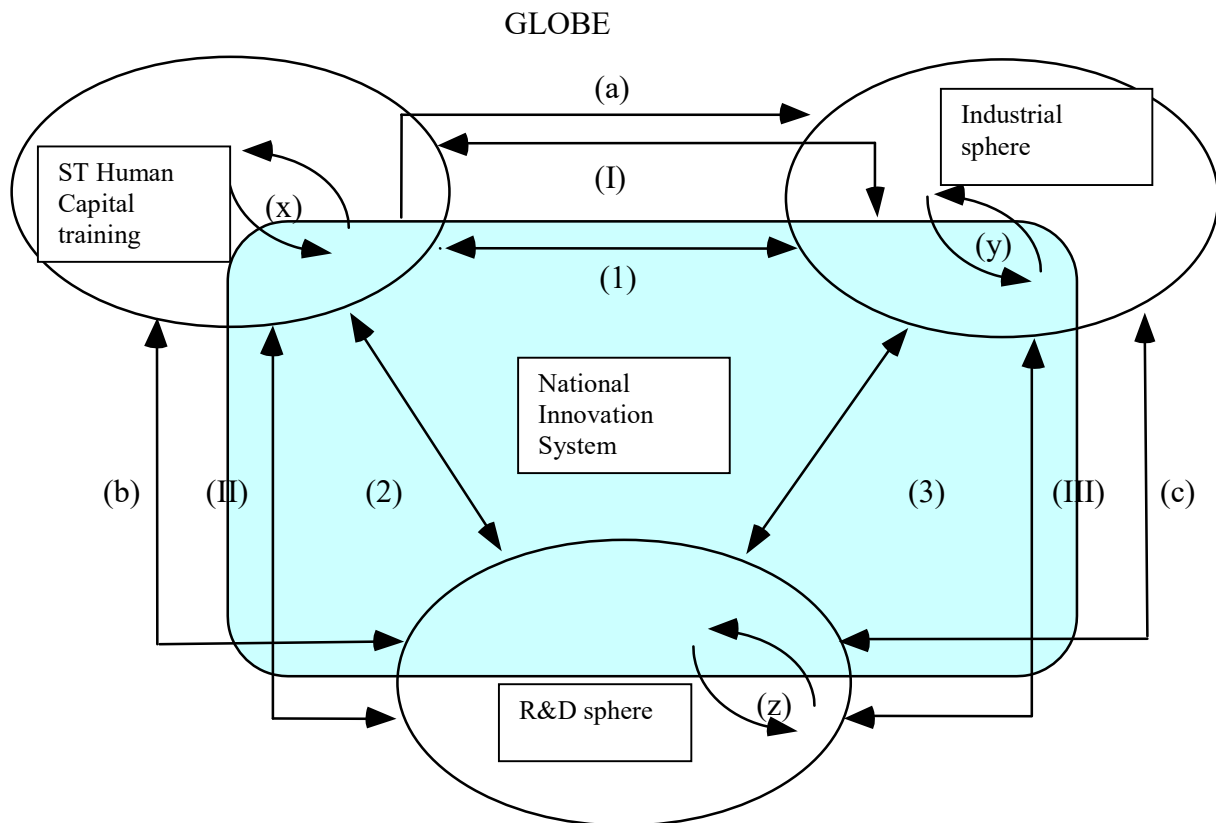
National science systems support innovation by generating themselves new relevant knowledge and by facilitating absorption of knowledge generated in foreign countries, the balance between these two functions varying with country size and S&T specialisation. Scientific specialisation profiles differ substantially across countries, are more contrasted in small than large countries, and tend to be quite stable over time. In small and medium-sized countries, scientific output in industry-relevant disciplines is well correlated with R&D intensity. Larger countries seem to enjoy economies of scale in translating scientific efforts into R&D, except the United Kingdom, where scientific output is inflated by prolific publications by the medical sector.

The evolution in the future depends also on some other features of their research system. The United Kingdom, and France have declining but still sizeable defence-related R&D investments.

National Systems of Innovation, Globalisation, and European Integration

In an European framework, consequently the question becomes twofold : on the one hand, it is worthwhile to analyze the evolution of the former nation-state innovation system, on the other one the possible emergence of an European innovation system. The concept of NIS has been elaborated to explain the different industrial and technological profiles which are exhibited by countries and especially the persistence of areas of strength in national economies which are associated with specific institutional configurations for very long periods (Saviotti, p. 167).

Among these configurations the flows circulating between the three different spheres, industrial, human capital training, R&D, which can be distinguished in the national economies are of special interest. It is very obvious that any of these spheres is closed. It has been emphasised for long that the scientific sphere has always been borderless and the increase in exchanges between domestic and global spheres dominates the usual rhetoric about globalisation.



National Innovation System³:

Johnson and Gregersen (1997) have discussed the various relations between economic integration and innovation. They distinguished four main types of integration according to the nature of arrangements and process (p.34).

Table 1 : Four main types of integration

	Designed process	Self-grown process
Formal institutional arrangements	I	II
Informal institutional arrangements	III	IV

Source : Johnson and Gregersen (1997)

Actually these types are not clear-cut and more or less interdependent especially during innovation process. The digitalized pan-European mobile communication network, GSM, shows how integration processes may effect both knowledge production and knowledge distribution through formal and informal institutional arrangements. The GSM standardisation initiative triggered off a wave of concentration and co-operation agreements (for instance precompetitive development joint-ventures) in the industry (Johnson and Gregersen p. 36) . It initiated - partly as a designed process, partly as a self grown integration process – greater R&D-collaboration on both the national and the transnational level.

Summing up their discussion of the influence of integration on national systems of innovation, Johnson and Gregersen (1997) wrote that integration will affect innovation both because there is a tendency towards greater cross-border collaborative use of knowledge stocks and a tendency towards greater transdisciplinary complexity in technical innovation. They concluded that “the empirical evidence of what is happening to national systems of innovation as a consequence of the integration process is still rather weak. It is not yet possible to say if they are losing out to systems on the European and/or regional levels or not.

³ Source Alcouffe 1995. As the different subsystems inside the NIS are related to foreign counterparts, the arrows show the flows circulating inside and outside the NIS.

Also the empirical evidence of an ‘autonomous’ European system of innovation in a broad sense is still rudimentary”. They found that “for the time being (1995-7) it is more reasonable to talk about an emerging European system of innovation in the narrow sense of the term”.

But before addressing directly these questions, we have to take into account that NIS as the SSIP approach recalls are not separated of the economic production and exchanges processes therefore it is interesting to look more closely to globalisation. Recently Neil Fligstein and Frederic Merand have sustained a provocative thesis along which the evolution of the world economy since three decades is less characterized by globalisation than by ‘Europeanisation’. “That is, a huge part of what is driving the increases in trade in the world economy is accounted for by the changes going on within Western Europe » whereas they see no evidence of a « single capitalist market ». They argue that an integrated market requires a single system of rules of exchange, property rights, and rules of competition and co-operation. The EU has by and large also come to co-ordinate rules of competition and co-operation for firms involved in trade across borders and even if there has been thus far less convergence across Europe in property rights, the European Commission has recently proposed the creation of a common incorporation label, *société européenne*, that should eventually undermine the currently national systems of property rights⁴.

Without following the detail of their argument, they show convincingly that (1) the importance of Western Europe in the world trade has not declined during the last decades, that (2) the concentration of EU trade towards Europe has substantially increased and that (3) for every country in the EU the concentration of trade towards Europe has continuously grown and substantially after entry for late comers.

Table 2: Share of intra- and inter-regional trade flows in each regions merchandise exports, 1999

	Destination				Total
	North America	Western Europe	Asia	Rest of World	
Origin					
North America	39.9	19.4	21.1	20.6	100.0
Western Europe	9.9	69.1	7.5	13.5	100.0
Asia	26.3	18.1	46.6	9.0	100.0

Source : World Trade Organization, Annual Report, 2000, Table III.3 – quoted in Fligstein Mérand, 2001

Table 3: Percentage of total manufacturing trade of EU countries with others in the European Union

	Austria	Belgium	Finland	France	Germany	Ireland	Italy	Netherlands
1970	53	77	21	82	70	27	70	68
1980	65	86	35	84	75	61	61	69
1990	79	83	41	86	79	54	67	77
1997	78	89	51	90	81	42	70	77

Source: OECD Outlook #64, 1998, p. 154 – quoted in Fligstein Mérand, 2001

On average, trade between European countries now accounts for approximately 40% of their GDP; indeed, 70% of their total exports are directed to one another. The main effect of the European integration has been to increase dramatically trade within Western Europe. European corporations have responded to these opportunities in several ways. First, they have undertaken mergers with their principal national competitors and many of their competitors across European borders. Second, European multinationals have become more Europe

⁴ Moreover on 1 August 2000, the Commission submitted a proposal for a Council Regulation on the Community patent. This proposal aims to create a single industrial title, a document which should be accessible and which should guarantee the legal certainty on a Community scale. Whereas the existing European patent, once delivered, is in practice a bundle of national patents, the Community patent would be a valid unit title immediately throughout the Community territory (http://europa.eu.int/comm/internal_market/).

focused in their investment and sales activities. Non-European multinational corporations have also come to focus more of their activities in Europe.

If Fligstein and Morand have very forcefully made the controversial point of “Europeanisation”, it is worthwhile to note that many specialists of international trade have remarked the polarization of exchanges in the so called triad. The specificity of Fligstein Morand is to emphasise the link between “Europeanisation” and political project on the one hand and strategical view of economic actors. Anyway there is a lot of evidence that in the industrial sphere, at least, national borders are no longer what they are used to be in Europe. Consequently Europe is by now an essential dimension of the markets for sellers and probably for producers too.

The national innovation systems and the dynamic of the global/local linkage

Even if we are to accept the Europeanisation thesis for trade and production, it does not follow that it holds for industry science relationships (ISR). Moreover in the EU, we have to take into account three levels in the focus when we are coming to ISR. (the regional, national and European levels). If they judge that the ‘national systems of innovation’ are still valid and central to the European scene Lundvall and Boras found that there have been important trends towards decentralisation and Europeanisation. On the contrary, *the lettre de l'ost* (2001) sustains that in this field, globalisation strikes in pieces the previous progress in Europeanisation : “Since the 1990's an important and increasing number of internationally technology alliances has replaced earlier national or even European alliances [...] and European companies invest heavily in R&D in the USA (in particular in the life sciences). The significance of this evolution should not be underestimated as ISRs have been structured around national research organisations and domestic firms at a time when the strategic interests of the different stakeholders converged easily towards national goals. The situation has evolved gradually during the 1970s and 1980s with the intensification of government-sponsored international co-operation in technological development, especially within Europe”. In our perspective, it is not easy to distinguish the possible emergence of an European innovation system from the pure geographical determination.

The geography of innovation

In the conclusion of a survey devoted to innovation geography, Massard states that, the efforts made to map innovation have shown the existence of local knowledge spillovers. These local features, however; are not necessarily the only way through which externalities are to be effective. They are combined with other; more overall geographical factors, as well as with sectoral and technological factors, as the result of complex processes.

The main question which arises therefore focuses less and less on the geographical element in externalities on the whole, and increasingly on specifying more clearly how these externalities are spreading and used to the full. Defining more clearly the complex modes whereby knowledge diffuses from one place to another is the main challenge to be met in order to understand the process of geographical polarisation which innovative activities have undergone, and above all, to assess the new trends occurring in this field. In addition, if the pattern of distribution of external resources shows the existence of significant differences between various geographical sites and countries, we will have to seek for new means of controlling the distribution of knowledge in space. Although the studies surveyed by Massard have yielded some partial results on these lines, further analyses are now badly needed to elucidate the following points in particular:

- the specific role of the players themselves and the direct contacts between them raise the question as to how much mobility is desirable for research scientists and high-skill jobs on the one hand and collaborative scientific projects on the other hand;
- the importance of the infrastructures conveying information and communications needs to be specified. Little attention has been paid so far to these infrastructures from the point of view of their effects on the spatial distribution of knowledge (by goods and persons in the case of transported knowledge, and more directly in the case ITC).

Although data on local R&D and innovation processes have been collected and carefully analysed in the SESI monographs as well in other surveys, we are still far to have at disposal proxies for knowledge flows⁵.

The origins of the proximity effects

Nohara Verdier come to the same conclusion regarding the IT industry in France, especially as regards the Grenoble region. They insist that the region has a long tradition of co-operation between industry and higher education in innovation networks, which emerged in the electrical engineering industry in the 1930s. The exchange of know-how and local synergies was maintained in the electro-chemical industry until the advent of the micro-electronic industry in the 1970s. It is undeniable that the Grenoble region had already hosted co-operation between local productive actors which would justify the title of "technological district", or local innovation system.

Alice Lam remarks the same features in the UK IT sector. She insists that "Proximity is important for building trusting and stable relationship with external institutions. Innovation intensive multinational firms go for 'global sourcing' of knowledge by locating their R&D activities in regions rich in knowledge and skills. Spatial distribution of learning activities is complemented by greater corporate co-ordination and control of knowledge transfer (Gerybadz and Reger 1999).

The evidence suggests that proximity to the University has facilitated the development of human resource links through student placement and recruitment, but not necessarily formal collaborative links. Given the characteristics of SMEs, students and graduate recruitment probably provide one of the most important mechanisms through which they absorb academic knowledge and new skills. SMEs often face recruitment difficulties and the shortages of qualified technical staff can inhibit growth and innovation (Senker 1996). Proximity to universities provides a recruitment advantage for them. For many SMEs, the importance of universities lies in their contribution to the formation of internal capabilities, and not necessarily formal knowledge transfer through research links. In fact, there are reasons to believe that formal research links might not be the most appropriate mechanism for knowledge transfer between universities and SMEs. Formal research links tend to be driven by the match of expertise and organisational objectives. Matching the needs between universities and SMEs is difficult because of the existence of a large gap between the type of research carried out in universities and the specific needs of SMEs. Knowledge transfer is a social process which requires social and organisational proximity.

Many studies have emphasized the proximity effect in the development of co-operation. For example, Brugarolas / Alcouffe conclude from their investigation in the data banks that proximity plays an important part in the cooperation between researchers and industrialists.

⁵ John Lovering expresses a very skeptical view on the literature on innovation geography :He argues that "the restructuring of defense shows tendencies that run precisely counter to those that many economic geographers claim to have identified as the emergent paradigm of economic geography--namely the economic empowerment of « regions » [...] However, the regionalized versions of the NSI literature is much less substantial than its National elder brother. [...] There is virtually no empirical content to the claims of the RSI writers

Geographical concentration facilitates the propagation of non stabilized and tacit information. Success in cooperations depend heavily on tacit knowledge. Trust is based on elements which are very specific as “home made” know-hows which are not transferable and remain tacit. Geographical proximity facilitates local learning based on tacit knowledge, frequent contacts and it reduces the possibility of opportunistic behaviors. Our investigation on contracts involving engineering sciences has proved, on the one hand, that industrialists are more likely disposed to call laboratories close to their research centers (90% of the cases in Midi-Pyrénées) and this proximity facilitates business relations. On the other hand, 40% of the contracts between Midi Pyrénées laboratories contract with regional industrialists (the same holds in Grenoble).

It cannot be omitted that the incentive policies developed by the Government and the Regional Council are designed to preserve or to increase this proximity effect. Policies supporting local endogenous development or local productive systems or scientific parks concur to the same results. This microeconomic model clearly acknowledges and takes into account the importance of institutions which supply constraints and incentives and lead to institutional arrangements. (see Brugarolas Alcouffe1999).

Proximity and global strategies of MNC

As governments are mistrusting more and more general programmes and policies in industrial matters, they pay more attention to these local effects and support the formation of *Clusters*, defined as “geographic concentrations of interconnected companies, specialised suppliers, service providers, firms in related industries, and associated institutions (for example, universities, standards agencies, and trade associations) in particular fields that compete but also co-operate” (Porter, 1990).

For example, in the UK, it is not considered the Government’s role to create clusters⁶. Clusters must be business driven and they form due to a variety of reasons, e.g. specialised demand, prior existence of related industries or institutions, or historical accident. Quality of life and other non economic factors can be equally important in determining growth. Clusters arise from making the most of synergies across and between companies and academic and research based institutions. The government, however, seeks to create the conditions which encourage the formation and growth of clusters. This can mean, for example, ensuring both national and regional policies do not inadvertently place barriers to cluster development, catalysing the formation of social interactions and collaborations within a cluster, and ensuring research and innovation support programmes build on existing strengths so as to work with the grain of cluster development. Government support for clusters, it is argued, cannot constitute a complete industrial policy. Cluster policy should be part of a wider set of policies that include national and non-sectoral policies and programmes that support and enhance nation-wide innovation and competitiveness, unfortunately it is difficult to guess what kind of contour such policies could take.

Simultaneously, the multinationals observed, notably North American, manifest a strategic desire to build a systematic, overall approach relative to their different commitments

⁶ See Alice Lam, July 2001. Related to clusters are science parks which are business and technology transfer initiatives that:

- encourage and supports the start up, incubation and development of innovation-led, high growth, knowledge based businesses.
- provide an environment where larger and international businesses can develop specific and close interactions with a particular centre of knowledge creation for their mutual benefit.
- have formal and operational links with centres of knowledge creation such as universities, higher education institutes and research organisations.

to the HERS. Their two strategic aims (and the resulting practices) are clearly distinguished from those of the 'national' companies. These two aims are not always in perfect harmony but reflect the presence of strategic co-ordination at a very high level of authority within these world-wide groups. On the one hand, there are the European ambitions which lead certain multinationals (Motorola, HP, pharma co. etc.) to place themselves immediately in the European space in order to seek out potential candidates for collaboration as broadly as possible, for example, by establishing a 'cartography of centres of excellence in Europe' or by casting a wide net over experienced engineers or researchers in the European labour market. On the other hand, they target what are sometimes called strategic partnerships, based on a lasting relationship with certain institutions of higher education. They thus develop a long-term, all-encompassing partnership with schools or universities, often those located nearby. What emerges, in the French case at least, is that the multinationals are not necessarily seeking to create partnerships with the 'best' schools or universities but rather to set up a dense network with local schools in order to constitute a veritable reservoir of new graduates. Such a partnership leads these firms to involve themselves systematically in very broad dimensions of the management of the universities/partners in order to influence the content of the academic curriculum as well as the engineers' professional profile and ultimately to attract the students best suited to their needs. In order to do so, some of these companies are members not only of the board of directors but also of the scientific board which determines the orientation of university research or various academic committees which define the teaching programmes. This participation in university governance is naturally accompanied by practical measures such as aid for courses, funding of facilities, organisation of internships for students and joint advising of doctoral theses or training of faculty. Beyond these classic means, which are used very systematically, they sometimes seek to influence pedagogical reform in the training of engineers by pleading in favour of teamwork and project-based learning, which make students aware of business environments. This kind of tight interweaving of company-university relations would ultimately seem to be aimed not so much at gaining access to the 'best talents' but at a more general revamping of the engineer/researcher profile in order to make it better adapted to changing technological and market conditions. According to the assessment of certain members of management, the French-style hierarchy of schools, based on academic excellence and the capacity for theoretical abstraction, is not always relevant to industry, which is confronted with the rapidity of technological change. Thus, the strategic partnership deployed by these multinationals may gain ground in a system which has remained relatively homogeneous and alter the national framework for the training of engineers/scientists.

"Pavitt and Patel provide significant evidence on three aspects of the innovative behaviour of large firms : first, multinational corporations are rather reluctant to locate technological activities in host countries. Core competences, including R&D and innovation centres, are still heavily concentrated in the companies' home countries. Second traditional industries are, in proportion, more internationalised than high-tech industries. The result is certainly significant since it indicates that knowledge-intensive productions are more dependent on territorially bounded competences. Third, when companies decide to move part of their R&D and innovation centres abroad, they generally select the fields of excellence of the host countries. In other word, companies are more likely to go abroad to exploit the national capabilities of other countries than to simply expand their own core competences."

But this concern with local externalities is not exclusive of global sourcing as the strategy of the European pharma firms shows⁷: In 1994, no less than 47 percent of the research conducted by the U.S. pharmaceutical industry was funded by U.S. affiliates of

⁷ See "Biotechnology Industry in the USA", Christoph Büchtemann, SESI Project WP 2.2

foreign companies. Examples of foreign companies that have made significant investments in U.S. companies include the following: Glaxo Wellcome (U.K.), SmithKline Beecham (U.K.), Rhone-Poulenc (France), and Pharmacia (Sweden).. Moreover according to the *NSF Science and Engineering Indicators 2000*, the funding of foreign-owned research facilities in the U.S. has grown substantially from 1987 to 1997: by an inflation-adjusted 10.9 percent per year, whereas the R&D funding of domestic firms in the same time period grew only by 3.9 percent per year (NSF 2000). In 1996, 10.4 percent of the R&D performance in the U.S. (\$15 bn) was funded by foreign firms, mostly from three countries: Germany, Switzerland and Britain. A part of this foreign R&D engagement, the NSF concludes, stems from acquisitions of U.S. companies by foreign competitors.

The trend of increasing foreign funded research within the U.S. has accelerated significantly in the last eight years. According to a study by Dalton and Serapio in 1993 (cited after NSF 2000), of the 255 foreign-owned R&D facilities⁸ in the U.S., about half were established only in the last six years prior to the study. In 1996, an update of the study counted 715 foreign-owned R&D facilities operated by 375 firms. The number and the activities of these facilities are concentrated mainly on pharma and biotech (116), chemicals and rubber (115) and on computers and software, instruments and medical technologies, electronics and automotive applications.

Labour market mobility

The notions of “national innovation systems” and “firm-level innovation space” which are central in the SESI project carry with them the strong implication that firms’ capacity to innovate is structured by their relation to society and is specific to the country in question. It is the outcome of various mediations constructed at national level. Among these various processes of mediation, higher education is assumed to play a fundamental role. Consequently it is very important to pay attention to the ability of international firms to monitor and assimilate the competences and knowledge produced in the various countries in which they operate. The findings of some previous research projects (albeit not very recent ones)⁹ “national technological systems” have remained relatively autonomous. Between 1981 and 1986, the basic research carried out in a given country continued to feed into a technological system largely under the control of national firms. In most countries, the links with foreign research and higher education systems established through personal contacts and recruitment remain relatively modest compared with national links. Nevertheless, our research has provided evidence that shortages of skills are leading to a more European recruitment by many firms.

In April 1997, 26.1 percent of holders of doctorates in S&E in the United States were foreign born. The lowest percentage of foreign-born doctorates was in psychology (7.2 percent) and the highest was in civil engineering (52.0 percent). Almost one-fifth (19.2 percent) of those with master’s degree in S&E were foreign born. Even at the bachelor’s degree level, 9.7 percent of those with S&E degrees were foreign born—with the greatest proportion in chemistry (15.9 percent), computer sciences (15.6 percent), and across all engineering fields (14.9 percent).

⁸ Defined as “free-standing” R&D structures outside of and separate from the parent company’s other U.S. facilities. This means, R&D departments or sections within U.S. affiliates are excluded from the count.

⁹ We are referring here principally to the research carried out by Patel and Pavitt (1991) on patenting inside a country by firms foreign to that country. The main finding shows that large firms still play a relatively small part in national technological activities; only in Belgium, Canada and the UK do they account for more than 15% of the total. Patent applications lodged in the USA by American firms in respect of activities carried out in France, Germany, Japan and the UK account for the following shares of all patenting in the country: 2.4; 6.9; 3.2; 16.7. However, these data relate to the period 1981-1986 .

Table 4. Number of foreign-born S&E degree holders, by place of birth, 1997

Country of birth	Number	Country of birth	Number
India	184 900	Greece	11 700
China	131 300	Spain	5 900
Philippines	92 800	Austria	5 400
Germany	84 100	Ireland	5 400
United Kingdom	74 600	Sweden	3 900
Italy	18 100	European countries	224 300
France	15 200	Other foreign place of birth	845 100

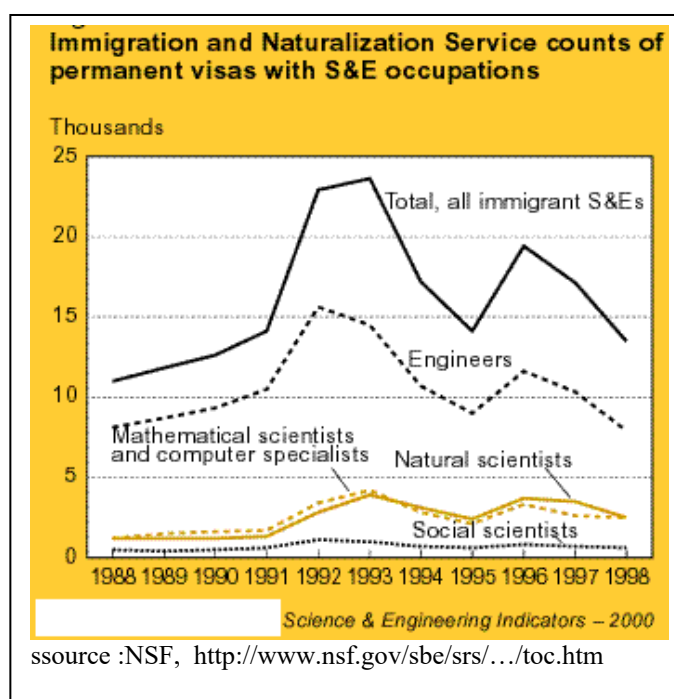
Source : NSF, <http://www.nsf.gov/sbe/srs/.../toc.htm>

As we analyze the relationship between industry and science it is interesting to note that a large part of the S&E foreign-born professionals have previously been students at graduate and postgraduate levels. According to a report by Finn (1999), 48 percent of 1992–93 U.S. S&E doctorate recipients with temporary visas were still in the United States in 1994. By field, this percentage ranged from 29 percent in the social sciences to 55 percent in physical sciences and mathematics. (See text table 3-25.) Within each discipline, the percentage of the Ph.D. graduation cohort found in the United States increases with years since degree, reaching 53 percent in 1997. The increase in the stay rate occurs despite considerable evidence from other sources that large numbers of foreign Ph.D. recipients with U.S. degrees leave the United States after completing a postdoc, or at later points in their careers. This suggests a very dynamic picture of the international migration of Ph.D. scientists—with some graduates of U.S. schools returning to the United States even as others leave. Sami Mahroum (1999) provides some data on European academics European doctoral graduates have a much higher stay rate in the US than their Korean and Japanese counterparts. The difference between Japan and Europe in the propensity to stay is large; only 8% of Japanese Ph.D. graduates stay. Graduates from the UK have the highest stay-rate in the US. Whereas, most German graduates go back (approx. 75%), only around 30% of UK graduates do. Greece lies somewhere in the middle between Germany and UK with a return rate of approximately 60%.

In the ISR perspective, it is interesting to note that in 1996 1000 of the Ph.D. graduates who started their own businesses in the US were Europeans (Mahroum 1999).

It is very clear that Europe is not attracting as many American scientists and engineers than the USA attract European ones. But these data should be used cautiously due to large incertitude. It seems that the emotion surrounding this topic has been enhanced by a burst at the beginning of the 90's whereas the trend seems to be declining :

Nevertheless it is remarkable that Europe (France, 171000, Germany 146000, United Kingdom 129000, Belgium, 35000, Swiss, 25000) attract 506000 foreign born students that is to say more than the USA (454000). From the French data, we know too that the percentage of these students who stay after their studies is roughly the same than the apparent figure for the USA (50%).



European countries are concerned by the shortage of skills and a possible brain drain by the USA. Because of their common language¹⁰, it is not surprising that concern in relation to the ability of companies in the UK to offer competitive benefit packages to attract leading people is high in the UK. Given the fact that leading researchers and managers are internationally mobile, and that there is a large demand for experienced managers, especially in biotechnology, it is considered imperative that more should be done to attract back some of the many managers and researchers who have gone to the US because of opportunities there. It is believed that an effective way of encouraging entrepreneurial spirit and attracting leading researchers and managers is through share options. In a government report it is explicitly stated that “the number of British entrepreneurs who have been attracted to work in the US biotechnology industry (...) is a trend we must reverse and ways must therefore be found to improve the attractiveness of share options” (DTI, 1999b:39). The decisions to provide incentives to enable companies to attract and retain the best staff, and the ability of growing companies to offer key staff tax-advantaged options over shares is a measure introduced by government to help resolve this problem¹¹.

The issue of international labour mobility and the ‘brain drain’ has received much attention in relation to science skills, this has especially been the case as the labour market for skilled scientists is becoming increasingly globalised both in terms of demand and supply. An Institute for Employment Studies research paper on ‘*Science Skills Issues*’ commissioned by the Skills Task Force suggested that there has been “no serious evidence supporting the notion of a brain drain from the UK or its impact on the UK skills base” (Pearson *et al.*, 1999: 19). However, leading scientists such as Denis Noble, professor of cardiovascular physiology at Oxford, and one of the founders of *Save British Science*, (see <http://www.savebritishscience.org.uk/>), have argued that there may not be a net brain drain but that British science has been decapitated by two decades of under-funding. (Winton and Perry, 2000). Also, various academics responded to government measures as insufficient to reverse the brain drain (Farrar and Weiss, 2000). The flow of scientists to the United States, which has been studied by the European *Joint Research Centre*, can have positive effects if international experience and expertise gained by researchers enriches the scientific community in Europe on their return. This suggests that positive international mobility of researchers should be promoted if they can also be encouraged to return (RTD *info.*, 25). In a report on this topic, Mahroum (IPTS Report, no. 29) states that in order to encourage the return of researchers and leading scientists, the private sector should play a bigger role by creating research and engineering centres of excellence in joint ventures with the public sector. Also, in a study of the ‘inflows’ of scientific personnel to UK academia, it has been argued that the increased foreign inflows reflect a decline of the local supply and increased demand for scientific expertise. It is cautioned that this increased supply of overseas scientists might make it less lucrative for local graduates to pursue an academic career in the UK, and that the benefits arising from the immigration of scientist are widely distributed in society,

¹⁰ Concerning the role of space in ISR recent results (Schartinger *et al.* 2000b p.13) found that distance and language are major barriers for projects to take place. The probability of partnerships to be established is much higher if the native language of a country is German. This is valid for academic partners and as well for firms

¹¹ In France, Michel Charzat MP had been charged by the minister of economy, Laurent Fabius with a parliamentary mission about the measures which could improve French attractivity. Indeed a report by Frédéric Lavenir, inspector of finances concluded that France has « a very bad image in the international executive circles » (see <http://www.finances.gouv.fr/minofi/>). But the minister of economy has avoided to give any hint on either a possible tax exemptions for international executives working in France, or on possible measures improving firm creation. Michel Charzat in his final report (July 2001, recommends special income tax facilities for scientists and international executive in order to make France more attractive, but puts more originally a great emphasis on the European level (especially he suggests to decrease the cost of patenting and reinforcement of the EPO).

with the costs being borne by native scientists. Therefore, it is suggested that the availability of access to international pools of highly skilled personnel should not serve as a substitute for training and investment in the local labour force and improvement of employment conditions (Mahroum, 1999).

But as detailed data for other European countries are missing, it is interesting to use the SESI monographs in order to see if European recruitment at the firm levels are becoming more international and possibly more European.

UK pharmaceuticals

Companies are increasingly recruiting Chemistry graduates in the wider European labour market. Pfizer, for example, reckons that it has now established a very good medicinal chemistry network on the Continent, and in France in particular. The company's 1998 recruitment figure showed that the proportion of Continental recruits in Chemistry was as high as 40 per cent. Similar development can be seen at ICI Quest: the company is now recruiting more continental European chemistry graduates than those from the UK. An added factor is that Continental European universities, French universities in particular, are more active in encouraging student placement, an increasingly important channel for graduate recruitment.

Pfizer is a global pharmaceutical company which has been experiencing rapid growth and expansion in the recent years. The company has expressed concern about the quality and standards of graduates from UK universities, especially in Chemistry. Moreover, it was pointed out that the general lack of practical laboratory experience and problem-solving skills among the graduates had become more apparent because of the rapid advancement in research techniques and changing demands of jobs in research. In recent years, the company has increasingly looked for graduates from Continental European universities. It also favours recruiting graduates with laboratory (student placement) experience.

Similarly, it is important to note that the development of strategic links with academic institutions is not restricted to the UK. Pfizer is increasingly casting its recruitment net wider by recruiting graduates from other European universities and forging research links with European centres of excellence. This is prompted by the need to search for the best quality scientists and to access a greater variety of knowledge sources. It is about a wider search for the 'potential of innovation' and the need to gain early access to 'new' and 'emergent' ideas.

The same observations can be drawn from ICI. Over the past few years, ICI's graduate recruitment has become more Europeanised. This partly reflects the increased globalisation of its business activities, but more importantly, continental European graduates are considered to be more qualified than the British ones because of their broader and deeper portfolio of competence and linguistic skills. The general decline in the standard of British chemistry graduates appears to be another important factor prompting the company to look towards the continental European labour market.

Even firms with a clear global scope are experimenting such an European recruitment. The example of UK-Pharma1 is especially highlighting. Central research at UK-Pharma1 is organised on a global basis. The research portfolio is co-ordinated globally, with a central committee overseeing the whole portfolio, covering the three main sites in the US, UK and Japan. Research teams and project managers located at different sites increasingly work in co-ordination with each other. The transfer of technology can be made to the operating divisions of any of the locations, not necessarily to the site where the drug was originally developed.

With the rapid advancement in research techniques and changing demands of jobs in research, the deficiency in practical skills and problem solving abilities among graduates has become more apparent. On the whole, the company favours recruiting graduates with

laboratory (student placement) experience. In chemistry, the company increasingly looks for graduates from Continental European universities. A senior executive in Discovery reported that the company had now established 'a very good' medicinal chemistry network on the Continent, France in particular. The 1998 recruitment figure showed that the proportion of Continental recruits in chemistry was as high as 40 per cent.

But this recruitment strategy is not only a response to labour shortage but clearly part and parcel of its competition and innovation strategies. It has recently started to generate a list of European centres of excellence by actively reading papers and identifying good research groups. The company is concerned about its relatively lack of a high profile in Europe. New initiatives such as organising postgraduate symposiums by inviting continental European scientists to present papers represents a first attempt to raise its European profile: The company is also keen to identify European funding for research as a means of building links with European research groups. It is increasingly aware of the importance of engaging in scientific dialogues with European research groups. The emphasis is on the importance of gaining *early access* to research outputs through networks of relationships:

The company's interest in tapping into the European science base is a relatively recent development. At present it is not engaged in any major research collaborations with European research groups, but initiatives in this direction may well increase in the coming years. A note of caution here, evidence from an earlier study by Senker et al (1996) suggests that public research organisations in some of the European countries (e.g. France and Germany), were not prepared to deal with a foreign company. They saw it as their duty to give first preference to national firms.

The links between UK-Pharma1 and academic institutions in recruitment and education have already been discussed. This section focuses on the company's external research links with universities and biotechnology firms. The company distinguishes two main categories of external collaboration: academic and corporate (i.e. biotechnology firms). In terms of the numbers of collaborative projects, the great majority are with academic institutions. However, in financial terms, 70 % of the budget is spent on biotechnology collaboration and the remaining 30% with academic institutions. For academic collaboration, about 70 % are with UK institutions and 30 % with those in the USA. In contrast, in the biotechnology area, the predominant majority of the collaborative ventures are with US firms. There is some emerging evidence that the situation might be shifting. A senior executive in Central Discovery believes that the ratio might be changing over time to be more European 'as the science works through there'. For example, interests in the German biotech scene is growing. The company has recently established a major collaboration with a German biotechnology company.

The small country case

Industry-Science Relationship in Austria

The Austrian industry is characterised by the overwhelming predominance of SMEs and a significant lack of big global companies. In this country R&D quota amounted to 1,79% in 2000, not comparable to remarkable achievement in the Scandinavian countries. In comparison to the international average (EU with 1,83% in 1997 and OCDE with 2,21% in 1997), Austria remains unchanged behind. Austrian business perform a mere 56% of Austrian R&D (What is significantly under the European average); on the other hand, universities perform 35% of R&D what is tremendously high compared to other countries.

The Austrian research system still exhibits a strong fixation on the national territory and on national property on research projects and programmes. Internalisation and globalisation of the research system still remain at a low level. For the EU as a whole, the share of GERD

funded from abroad was 6,5 percent in 1995. In Austria, the percentage of GERD funded from abroad was 2,5 percent in 1995, which is still well below both the EU average and that of other small open economies. The internationalisation of Austrian research, in particular that of the higher education sector, is still at a relatively low level. The Austrian participation in the European R&D programs is in most areas still under the European average. Schartinger et al. (2000) found that the Austrian university departments quantitatively prefer a type of interaction that do not necessarily include a recurring face-to-face contact between universities and industry. In this survey the joint supervision of PhDs and master thesis, lecturer by firm members at universities and contract research had the biggest share of responses. The geographical proximity has an important role in the knowledge transfer. Concerning the role of space in ISR recent results (Schartinger et al. 2000b) exhibit that almost three quarters of all project partners of Austrian universities come from European countries, the highest proportion of which, almost 40 per cent, come from Austria itself.

Concerning the role of space in ISR recent results (Schartinger et al. 2000b) found in a survey of 19.688 relations between an Austrian university department and a project partner that Project partners of Austrian university departments in the performance of research projects come from 87 countries of residence in total. They can be distributed in categories of distance along their location (Austria: 41% Neighbouring countries: 28% (among them Germany: 16%) rest of Europe: 17% Other countries: 14% (among them USA: 8%). National data as well as firm monographs show that the opening of the Austrian system of innovation is predominantly European, but with intended and significant linkages with the USA.

Austrian manufacturing mainly is engaged in rather traditional Fordist industrial sectors with a rather outdated production structure – characterised by being 'raw material heavy' - and has a major deficiency in the rather new technology supported sectors of the knowledge based economy. The strong position of a sheltered public sector and nationalised companies guided more by political goals than by market principles reinforced the Austrian system of incremental innovation. According to Lundvall/ Nielsen (1998) a major factor influencing innovation trajectories can be found in the competition regime: A strong exposure to competition and transformation pressure is tending towards triggering product innovations, stimulating organisational change, moving firms toward learning organisations and networking organisations and increasing the skill requirements in firms. Since wide areas of the Austrian economy have been sheltered from international competition this 'competition incentive' to innovation, up-grading of skills and co-operation did largely did not exist. Therefore innovation in Austria is a mainly driven phenomenon. It is not very research intensive, it rather means to adapt and adjust standardized products developed somewhere else to requirements of Austrian customers. role. As a consequence the linkages and interaction of the higher education sector with the business enterprise sector are weak in terms of flows and funds.

In 1989 Austria applied for membership in the EU, 1994 Austria joined the European Economic Area and in 1995 it was admitted with full membership in the EU. The biggest economic impact of EU membership was expected in strong transformation pressures on the sheltered sector in form of stepped up competition (Lauber 1996, 143). This process has been under way now since six years forcing Austria to revoke the sheltered sectors and to adopt European rules for market competition. With respect to competition Austria now has adjusted to European average. It is interesting to look at this adjustment in a particular sector as the ICT. The center of the Austrian production in the telecom-sector still consists of four companies: Siemens, Alcatel, Ericson/Schrack and Kapsch. For all this firms, the 1990s was a period of profound change with regards to academic institutions. Each of the case studies in the ICT sector is following an own specific course towards the knowledge based economy

having a different focus on the possible strategies of knowledge sourcing and giving a different weight and a different moulding in that process.

Following the Austrian catching up, some concerns have appeared about skill shortages. Kurt Mayer tells the interesting story of Kapsch, an Austrian SME in the ICT sector. In the second half of the 1990s the company hesitantly approached universities but only some minor agreements resulted from that activities (some diploma thesis, on PhD thesis, one small scale project having the nature of outsourcing a well defined problem to a university assistant). Nevertheless in the recruiting of human resources – especially faced by the ICT skill shortage since 1997 -- the company increased its activities to recruit graduates (with marketing events for graduates, participation on firm fairs at universities and by outsourcing R&D activities to newly established small competence centers in the environment of universities (eg. Graz or Budapest)).

Since other research reports point to similar problems (see ARCS/ IHS 2000) shortage of *qualified staff in the ICT* sector could be remedied by policy efforts in three directions:

1. to increase the number of graduates in the HES
2. to develop training courses to boost the number of qualified workers in the long term.
3. to open the borders for ICT professionals from abroad, especially from Eastern Europe.

The last point should be facilitated with the coming enlargement of Europe which will bring all part of the former Habsburgian Empire under the same roof, but to this point the economic needs are at variance with the credo of the FPÖ, the sulphurous partner of the ruling coalition in Vienna.

Industry-Science Relationship in Portugal

In the Portuguese case, globalisation or internationalisation cannot be said to destroy a national innovation system or to weaken national ties or links, because those ties have always been inexistent or weak. What we can say is that, in spite of all the public policies – including funding – to promote those ties, there is no system. This is because the industrial specialisation in traditional sectors, the international division of labour that maintains Portugal specialised in the manufacturing process and the weakness of science based sectors. In this context, European R&D programmes appear an opportunity for Portugal and it is remarkable that Europe finances the most of the research made in consortium between firms and universities involving several European countries whereas transatlantic programmes do not exist in Portugal¹². More generally foreign firms are very important both as sources of innovation, clients and access to foreign markets Training young recruits abroad is also important in the telecommunication sector for multinational firms operating in the country, namely Siemens and Alcatel. But this is mainly training in in-house laboratories located in France, Germany, etc.

There are examples of increasing recruitment from abroad in the IT sector (informatics and telecommunications), mainly from East European countries, to work in firms and some intermediate institutions¹³. The main reason is the lack in the internal labour market (mainly due to the liberalisation of Telecommunication National operator and the emergence of new firms in this area) and the pressure on the increasing of wages.

¹² Some intermediate institutions, closely linked to universities (see INESC case in IT sector monograph to understand the meaning of an “intermediate institution” in the Portuguese case), are doing research (basic research) for American firms, due to the lack of interest of Portuguese firms in academic knowledge.

¹³ Cf. Oliveira, Luisa, (2000),” Informatics and Telecommunication Monograph: the case of Portugal”, in Verdier, Eric (coord), Innovation et Systèmes d’Enseignement Supérieur, project financed by TSER programme, DG XII, Brussels

Human Mobility does not concern only young recruits, but also people that is not yet in the labour market. For instance, science policies are particularly important, by financing scholarships abroad. This is one of the most important criteria of mobility and internationalisation of national research system (not innovation system), as it is questionable if we can talk about an innovation system in a country were the most of the firms do not use academic knowledge and we do not have headquarters of transnational firms).

But opening in the Portuguese case does not mean alliances. With a few possible exception, co-operation takes generally the form of dominance relations, depending on the “competitive platform firms are located”¹⁴. Portuguese firms just sell, under certain conditions - defined by clients -, their knowledge. P1-Por monograph shows that the products are sold together with detailed technical reports, meaning that Portuguese firm has no property rights on that knowledge.

European S&T Policy and National Innovation System.

Government and foreign funding

The most notable trend among the G-7 countries, during the last decade, has been the relative decline in government R&D funding. Indeed, this pattern of reduced governmental R&D support is apparent throughout the OECD, and especially in European countries (Caracostas and Muldur 1998). In 1997, roughly one-third of all R&D funds were derived from government sources—down considerably from the 45 percent share reported 16 years earlier. Among all OECD countries, government accounts for the highest funding share in Portugal (68 percent of its 1997 R&D total) and the lowest share in Japan (19 percent in 1996). Part of the relative decline reflects the effects of budgetary constraints, economic pressures, and changing priorities in government funding (especially the relative reduction in defense R&D in several of the major R&D-performing countries—notably France, the United Kingdom, and the United States). Part reflects the absolute growth in industrial R&D funding as a response to increasing international competitive pressures in the marketplace, irrespective of government R&D spending patterns—thereby increasing the relative share of industry’s funding vis-à-vis government’s. Both of these considerations are reflected in funding patterns for industrial R&D performance alone: In 1981, government provided 23 percent of the funds used by industry in the conduct of R&D within OECD countries, whereas by 1997 government’s share of the industry R&D total had fallen by more than half, to 10 percent of the total. In most OECD countries (as in the U.S.), government support to business R&D is skewed toward large firms (OECD 1999a)¹⁵.

The R&D funding share represented by funds from abroad ranged from as little as 0.1 percent in Japan to more than 16 percent in the United Kingdom. Foreign funding—predominantly from industry for R&D performed by industry—is an important and growing funding source in several countries and reflects the increasing globalization of industrial R&D activities overall. Although the growth pattern of foreign funding has seldom been smooth, it now accounts for more than 20 percent of industry’s domestic performance totals in Canada

¹⁴ Cf. Oliveira, Luisa, (2000),” Informatics and Telecommunication Monograph: the case of Portugal”, in Verdier, Eric (coord), Innovation et Systèmes d’Enseignement Supérieur, project financed by TSER programme, DG XII, Brussels

¹⁵ In transatlantic comparisons, it is frequent to complaint that European countries perform poorly in technological fields comparatively with scientific ones relatively to the USA. This should be related to the part of basic and applied research funded by governments. Basic research accounts for more than 20 percent of total R&D performance reported in Italy, France, and Germany when the United States expends only about 17 percent of its R&D on activities that performers classify as basic research.. (Data are not available for the United Kingdom).

and the United Kingdom and approximately 10 percent of industry R&D performed in France and Italy. (See figure 2-32.) Such funding takes on even greater importance in many of the smaller OECD countries, as well as in less industrialized countries (OECD 1999d). In the United States, approximately 8 percent of funds spent on industry R&D performance in 1996 are estimated to have come from majority-owned affiliates of foreign firms investing domestically. This amount was considerably more than the 3 percent funding share provided by foreign firms in 1980.

The European IT and telecom case

The IT and telecom sector provide us with case studies in order to analyse the dynamic of European national systems of innovation and the effectiveness of European programmes in order to build up an European innovation system. Given the overwhelming force of the American IT industry, including in terms of software packages and IT services, Europe certainly seems to suffer from structural deficiencies inherited from past “national champion” policies. Despite these weaknesses, some European countries seem to be showing their capacity to resist the American offensive, drawing on knowledge, competences or positions linked to their own institutional set-ups. In particular, the case of France, which in the past systematically developed state policies in favour of IT, shows us how actors in the innovation process rely on existing institutions to revitalise their innovation activities.

After the relative failure of national policies, the European programme seemed to be an opportunity to challenge American pre-eminence. Despite these efforts, it may be noted that the Esprit series of European programmes had no effect on existing co-operative networks and did not replace them with new arrangements. Naturally, the Esprit projects in which Bull and Thomson, as well as many software and IT service companies and research institutions such as INRIA and university teams, were active participants, allowed research networks to be extended on a European scale and brought the various players in the European IT industry closer together. From the French perspective, however, the constitution of European networks has taken place within existing local and co-operative arrangements, notably those focused around regional centres. Being established in a locality does not, therefore, seem to conflict with the extension of co-operation between the industry, universities and public research to the European scale (Hiroatsu Nohara and Eric Verdier, 2001).

In 1983, the Commission of the European Communities undertook a vast programme of activities concerning telecommunications. This led to the publication of the 1987 Green Paper, followed by the liberalisation of the equipment and service markets. The principle of opening voice telephony to competition was adopted in 1993, with a calendar extending from 1998 to 2005 depending on the country.

The EEC's interest in questions related to the new information and communications technologies goes back to 1983, with the creation of a special task force on "Information and Telecommunications Technology". Three years later, this task force was merged with other departments to become the European Commission's DG XIII, responsible for telecommunications and the information industries. From 1984 to 1987, Community policy on telecommunications was organised around six kinds of actions:

- i) co-ordinating the development of the supply of services;
- ii) developing a single market for terminals and equipment;
- iii) supporting the pre-competitive R&D programmes ESPRIT¹⁶ (on information technologies) and RACE¹⁷ (on broadband networks);

¹⁶. European Strategic Programme for Research in Information Technologies.

¹⁷. Research and Development in Advanced Communications Technologies.

iv) launching several programmes to encourage exchanges of information between European bodies and national government;

v) aiding the introduction and development of services and networks in outlying regions (STAR¹⁸);

vi) adopting common technical specifications (GSM, MAC).

At the regulatory level, the Green Paper published by the Commission in 1987 set three objectives for 1992: total liberalisation of the terminals market, the possibility of interconnection for service providers according to "open" networks principles and the clear separation of regulatory and operation activities.

i) It is an industry that structures its environment because it provides equipment giving rise to new demands and new activities. It has gradually assumed a dominant position in the industrial fabric.

ii) It is a high-tech industry that requires very costly R&D investments and a sufficient scale to cover such irreversible expenditures. It has already experienced a fundamental technological discontinuity with the shift to time switching, just as it has experienced rapid technological change with the importance of software in relation to hardware or with the role of mobility for terminals, and it might be sharply destabilised by the accelerated development of optics.

iii) Technological change in this industry leads to profound transformations in knowledge, skills and know-how that are essential to manufacturers. The boundaries with other industries are shifting and porous and often lead to new strategic positions for manufacturers seeking certain access to the latest key skills.

iv) The environment of this industry is subject to the effects of the deregulation of telecommunications services, videocommunication cables and television.

v) Its strong national character is outmoded. Formerly multinational, it is becoming increasingly global, with a displacement of both geographic centres of growth and high-potential activities that reflects sharp international competition.

Major industrial battles are currently underway for the conquest of markets located at the juncture of the telecommunications, computer technology and audiovisual industries. Sector-based divisions seem to be flying into pieces from the pressure of the major players in each of these sectors seeking to enter the markets of the other two. Although the current recomposition, which is far from over, can be traced back to the 1980s, it has been sharply accelerated since the beginning of the 1990s. It is manifested by a strong interpenetration of players and actors from the three sectors, but the industrial organisation (i.e., the configuration of these players and markets) that may result from the breakdown of sectoral boundaries and market transformation is still largely undetermined. Amongst the possible configurations, the most frequently suggested is that of 'convergence'.¹⁹ Developing similar technologies, the main players in these sectors would be called upon to integrate the activities of audiovisual technology, computer technology and telecommunications. At the end of the process, we would have a few large firms intervening on a market that would indeed be differentiated but

¹⁸. Special Telecommunications Actions for Regional Development.

¹⁹. The question of convergence is not new; it was already raised in the early 1980s, although at that time it involved only two kinds of players, coming from the worlds of computer technology and telecommunications. Grand manoeuvres and battles were announced, notably between the two giants of American industry, ATT and IBM. Notwithstanding a few skirmishes, however, the battle did not take place. Ten years later, the question is raised once again, and the stakes related to the opening of the sectors are much more important. Two reasons may be cited: first of all, a third sector has come on the scene--that of audiovisual technology--and second, the deregulation movement that was just beginning in the early 1980s has since gained strength, which permits greater interaction between the sectors.

defined by a global need--that of access to information services whose previously separate forms of processing and communication (voice, image, text, data) would be integrated in a reunified communications process.²⁰

The 'convergence' thesis is illustrated by the circulation of a few vague metaphors such as "information highways" or "multimedia", which attest nonetheless to the way the players represent their actions. Rallet (1996) nuances this thesis by showing first of all that technological convergence is a differentiated movement that does not do away with the specific features of the skills on which the division of labour between the various types of players is based. He then brings out the relative indeterminacy of the possible trajectories for the industrial organisation of the three sectors.²¹

Generally speaking, the telecommunications sector is organised in a context of uncertainty leading to what Badillo (1996) calls "technological and regulatory slack".²² In such a context, the actors' strategies are preponderant and motivated by the prospects of high returns from the telecommunications market. It is doubtful that in such a framework public policies even at the European level could still play a structuring role in the future..

Concluding remarks

We started with some observations about the paradox represented by the success of the NIS concept in the face of globalisation. We discuss the phenomenon and distinguish between internationalisation per se and Europeanisation. This leads us to look after hints of a possibly emergent European system of innovation which could mirror the well documented European system of production which results from European integration. We found that labour mobility for scientists is rapidly increasing in Europe favoured by skill shortages. Nevertheless it is very clear that knowledge sourcing which is very important in firms' strategy, even at the SME levels is global and the picture we got is very different of an European fortress. To this point, we disregard an important phenomenon which is probably linked to the success of the NIS concept. Actually, new growth theories as well as policy inspirers emphasise the difference between social and private returns on R&D investments. Muldur argues in this vein that "the social return on R&D investment is not only very high, but it is also greater than its private return" (Muldur 2001, p. 120). The first part of the sentence is doubtful and it will be difficult to define a scale in order to measure these heights, but the second one will probably reach a large consensus among economists. If it is right, then we find a *raison d'être* for policies designed to reduce the gap between social and private returns. The indicators gathered by the European Commission produce convincing evidence that the top firms in the European Union are making R&D efforts very similar to their transatlantic counterparts whereas the European SME lag largely behind. The under-investment in R&D on the part of European industry compared with American industry is explained in the main by shortcomings in the lower stages of the industrial structures and not by a lack of investments on the part of large European companies. Muldur 2001 (p.150) argues that the under-investments by European SMEs in research and innovation could be explained by allocative inefficiency (the lack of access to national programmes for SMEs) as by organisational inefficiency (barriers to the start-up and development of new innovative enterprises, lack of

²⁰. Giving rise to what Badillo (1996) calls a "mega" communications industry.

²¹. For further details, see Rallet (1996).

²². The term *slack* is borrowed from organisation theory (Cyert, March and Williamson), but Badillo's concept of technological and regulatory slack is clearly somewhat removed from that of organisational slack. The parallel between the two is the following: just as there is company play within the company, the convergence of information technologies and the market organisation correlated to it takes place with a certain play, in conditions that are less than optimum. The distance between ideal and real organisation thus reflects the technological and regulatory 'slack'.

cooperation with the universities). It is considered that a substantial increase in public and private funds for SME will achieve the desired results if this is accompanied by measures and dismantling the barriers to innovation, the business creation and the expansion of SMEs.

Nonetheless several SESI monographs show that European SMEs are not unable to engage in R&D and innovation. Unfortunately their linkages to the HES remain weak and could be one of the factors which prevent the European innovation system to develop and catch up the American one. Consequently among the policies designed to dismantle the barriers to innovation, the business creation and the expansion of SMEs, an important part should be devoted to develop the cooperation between HERS and SMEs.

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