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The Challenge of Innovation Based Competition:
A Transatlantic Perspective on ICT

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Introduction

The fast pace of growth in the United States since the 1990s has been partly due to the ability of the American economy to take advantage of the accelerated pace of innovation and the diffusion of information and communication technologies (ICT). If there is such a phenomenon as the new economy, it is, to a large extent, innovation based growth. Europe has been in a much less favorable position over the last decade. Macroeconomic factors partly explain the differential; in particular, the European economic outlook has hardly favored investment for a number of years. The macroeconomic context is not the whole story though as the composition of investment has also been quite different on the two sides of the Atlantic. In particular, over the 1990s, Europe has invested relatively more in physical capital and relatively less in knowledge than the United States.[1] As a result, Europe exhibits a lower knowledge investment intensity.[2] Part of the gap in knowledge investment is to be attributed to lower investment in R&D by the private sector. Is this observation related to the so called "European paradox", i.e. the fact that EU countries produce world class scientific research but have been unable to generate innovation based growth?

Since the 1980s, concerns about Europe's lagging technological performances have re-emerged. Not unlike the American challenge of the 1960s, this new "technological gap" is actually an "innovation gap" which is to a certain extend rooted in organizational and institutional factors. Taking the latter into account, as suggested by the growing body of theoretical and empirical literature on the processes of innovation, goes a long way in explaining the "European paradox". The paradox only exists if, firstly, European basic research is really world class[3] and, secondly, if scientific resources are considered easily harnessed into the innovation process and commercial exploitation. If multiple interactions have to take place between universities,

[1] Investment in knowledge includes spending on education, ICT expenditures and R&D expenditures.
[2] Knowledge investment as a percentage of GDP. Among the triad, the U.S. has the highest intensity and Japan the lowest (Soete 2000).
[3] Which may not be the case precisely in ICT (and biotechnology) as suggested by Pavitt (2000a).

innovative firms, suppliers and market perceptions, then organizational considerations, as well as the institutional context may either foster or hinder the process. The literature on national systems of innovation for example explores these multiple interactions. More generally, studies of the social process of innovation have greatly contributed to the present focus of numerous economic analyses on institutional factors.

Part 1 is an attempt to pinpoint the most important institutional differences between the United States and Europe in nurturing leaders in innovation based competition, with a focus on ICT. The findings largely support previous research on the subject, but emphasize the crucial importance of the US *business ecology*[4] which tends to foster start ups, including when it means that established companies are hurt, as their assets and competencies are destroyed. This environment happens to be particularly adequate for the current wave of innovation in ICT (and biotechnology). US policies have nevertheless reinforced this adequacy by both providing yet stronger incentives to start new technology based firms and stimulating the competitive process. In other words, the American business ecology promotes intense creative destruction, which has been further stimulated by public policies since the 80s.

Part 2 analyzes European responses, including firms' strategies and public policies. European firms are trying to source technology directly from the leading American clusters through various channels. Public policies on the other hand have progressively modified national systems of innovation. The analysis of the EU technological policy suggests that the move to a more truly European perspective could be the most promizing way to respond to the new American challenge. Since the first "American challenge" (Servan-Schreiber 1967), large European firms have taken steps to operate at the European and global levels. The Single market has provided for a larger and more unified market to exploit economies of scale. In the new paradigm, research may constitute a further step in integration.

The conclusion briefly discusses the sustainability of the intense American creative destruction process and the issue of convergence between national innovation and business systems.

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[4] This term is used without particular emphasis by Cohen *et al.* (2000); I have found it particularly apt to convey what I find important in the systemic effects produced by institutions and policies. Giesecke (2000) uses this term in the case of biotechnology in the same spirit.

1. Innovation and diffusion in the information age

Innovation based competition has had radical consequences on corporate R&D practices by firms. The American innovation system and business environment, which were considered ill adapted in the 1980s, have proved quite adequate to this new paradigm, especially in ICT.

1.1 The challenge of innovation-based competition

Since the 1980s, as the result of dynamic interactions between technical progress and globalization, innovation has become ever more central to firms' competitiveness. The role of generic technologies such as electronics and biotechnologies has often been underscored as a powerful source of pervasive innovation across sectors. However, the accelerating pace of innovation based on such emerging technologies over the last two decades owes much to increasing competitive pressures, which in turn result from globalization of markets and production. One important aspect of this trend has been the development of more sophisticated productive and technological capabilities in emerging countries. Korea and Taiwan in particular have upgraded from low-cost subcontractors to low-cost imitators and are striving to become low-cost innovators. They are investing increasingly in R&D and feature the fastest-growing US patent activity.

As a result, competitors from advanced countries have specialized on more innovation-, service- and marketing-intensive segments. In advanced countries, innovation-led competition is thus sustained through both the rapid introduction of new products in a wide range of sectors and more radical innovation in high-tech sectors. Over the most recent period, digitalization has stimulated a new source of innovation, with convergence between sectors creating multimedia products and services.

In the context of innovation-led competition, all sectors tend to experience an increasing pace of innovation, but technological progress is qualitatively different across sectors. In a great many number of cases, firms speed up to introduce new features in traditional products, while in some high-tech sectors, innovation tends to draw more directly on frontier technology and cutting-edge science. As a result, while the total number of patents has been on a rising trend since the 1980s (OECD 2000), their characteristics vary among sectors. While sectors tend to experience shorter technological cycles, only some of them draw substantially more on scientific work.[5] Pharmaceuticals and biotechnology are such areas: during the 1990s their patents have tended to cite non-patent prior-art references much more. Information technology exhibit particularly rapid technological cycles, but also tend to rely slightly more on basic research in the 1990s than in the 1980s (Alberts 1998).

A number of technologies tend to converge and products and services become more complex. As a result, firms not only need to be more competent at innovating in one core technological field, but also increasingly have to master a broader set of technologies, both to diversify and to be able to combine technologies. Empirical studies have indeed shown that large firms do diversify their technological base (Grandstrand *et al*., 1997).

Evolution of R&D management

Large firms have long invested to take advantage of economies of scale and scope. As they have diversified, they have implemented new organizational structures in order to reap economies of scale and scope (Chandler 1962, 1990). In the context of innovation-led growth and globalization, they now also have to organize to both accelerate innovation and broaden their spatial reach. Firms are thus pressed to increase simultaneously economies of scale, scope, speed and space. Pressures are strongest on technology-based firms which constitute a growing sub-species of the modern business firm (Grandstrand 1998), but are actually quite pervasive as globalization and technology underlie a larger set of business opportunities.

Innovation-based competition has deeply influenced R&D practices. Four interdependent developments may be briefly identified as contributing to the adaptation of R&D processes: intensification of R&D spending, externalization, cooperation and internationalization. These trends have been strongest in high-tech fields but have also influenced restructuring in other sectors such as the automobile industry or chemicals. Firms have had to choose from a larger set of technological opportunities while they have also had to churn out new products and solutions at a faster pace. As a result, they have increased the resources they devote to R&D while simultaneously resorting to external resources. The latter evolution is related to the more general restructuring and vertical disintegration trends and corresponds to the same underlying rationale, i.e. the need for firms to focus on narrower sets of activities, precisely to reap the four types of economies mentioned above. Firms need to harness more diversified resources and to

[5] Both these evolutions can be measured by using the material cited by patents ; see (Alberts 1998) for

do so more quickly, so that they tend to reduce the scope of their activity. Accordingly, more focused activities reflect the need to broaden the set of resources and competences which firms have to master or coordinate in order to compete.[6]

Firms cannot internalize all the competences they need in order to innovate, as was the case in the 60s and 70s. As technology becomes increasingly distributed and decentralized, they need to draw on a larger set of rapidly evolving technologies. Moreover, as they are obliged to develop products rapidly, they have to ensure that their own process of innovation runs as smoothly as possible. This requires strong integration and coordination capabilities. Firms have thus developed new organizational approaches. Internally, the basic idea has been to empower project teams or integration teams to accept responsibility for combining internal and external R&D resources.[7] Organizational innovations have however also been necessary to draw adequately on external resources. This need has constituted one of the main determinants of the exponential development of cooperative agreements since the 1980s. Indeed, firms cannot simply buy R&D capabilities through licenses as they need to engage in cooperative patterns in order to conduct increasingly complex and multidisciplinary projects.[8] Accordingly, the pervasiveness of cooperative R&D and networking reflects the adequacy of these organizational answers to the current constraints of innovation management. This being so, high-tech firms tend to resort to technological alliances particularly intensely. Pharmaceutical groups have tens or hundreds of alliances, and computer or software firms also cooperate with numerous partners. In a number of cases, a dozen or more independent firms form a "constellation" (Gomes-Casseres 1996) to increase externalities. This is the case for example when standard-setting is at stake.

One important area for cooperation results from the decreasing share of basic research in firms' R&D. Increasingly, as product development cycles shorten and competitive pressures rise, they look for external sources of basic research. This trend results in tighter relationships with universities in particular (Branscomb and Keller 2000). These relationships are particularly important in sectors where firms tend to draw more heavily on science, such as biotechnology or

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indicators based on patents citations.

[6] Financial market pressure has also contributed to this trend, which has generated numerous mergers and acquisitions during the 1990s.

[7] There is a vast literature on this process. Case studies include in particular automobiles (Clark and Fujimoto 1991, Midler 1993) and semiconductors (Iansiti and West 1997).

[8] The literature on cooperative agreements is also huge, with both theoretical and empirical contributions; a number of references are quoted in section 2.

some of the ICTs.

Internationalization constitutes the fourth adaptive behavior in the evolution of R&D management. It is examined below as the internationalization of R&D has to be understood in the more general context of globalization and has particular importance for the analysis of transatlantic differences and interactions.

Globalization and R&D decentralization

There has been a slight increase in foreign R&D activity over time, in line with the increase in the activities of multinational corporations abroad. It thus comes as no surprise that foreign R&D has been increasing more strongly since the 1980s, first along with the surge in FDI during the 1980s, and again after the crisis of the early 1990s. Table 1 indicates that the countries for which foreign patenting has increased most have been among those where FDI has grown the most, like Japan or France. Germany, the UK and Switzerland have also substantially increased their share of foreign patents. A number of European countries now derive a substantial part of their patents from R&D units located abroad. This is not only the case for small countries like the Netherlands and Belgium, but also of the larger countries of the EU. More foreign patenting corresponds to more R&D spending abroad by multinationals and an increasing foreign share of national R&D spending.

Table 1. Share of US patenting of the largest nationally owned industrial firms due to research located abroad (per cent)

Country of origin	1940 - 1968	1969-1990	1985-1990	1992-1996
United States	3.6	6.8	7.8	8.0
Europe	26.6	27.1	n.a	22.7
Germany	8.7	13.7	14.9	21.8
France	8.2	9.5	14.3	34.6
United Kingdom	41.9	43.2	42.1	52.4
Italy	24.8	14.2	11.8	22.1
Netherlands	29.5	53.0	57.8	59.9
Belgium	53.9	60.6	62.8	66.8
Sweden	13.2	25.5	39.2	36.0
Finland	-	-	18.0	28.8
Switzerland	28.3	43.8	46.7	58.0
Japan	-	-	1.0	2.6

Sources : (Cantwell 1997, Dalton and Serapio 1999*)*

Table 2 emphasizes inter-regional differences among countries from the Triad. Japanese firms have retained a very centralized organizational structure, even if the rate of internationalization is impressive. European firms have internationalized their R&D beyond the

EU. The table shows that patents developed outside Europe have increased much more (149%) than patents developed within Europe (70%). Most of the patents developed outside Europe originate in the United States. This tropism is discussed in section 2, which provides data on the different modes of technology sourcing by European firms in the United States.

Table 2. Percentage of US patents developed outside the country/region by large companies*

	1985	1995	% increase between 1985 and 1995
US firms	6.0	12.3	105
Japanese firms	2.0	2.9	145
European firms outside the EU	5.1	12.7	149
European firms in EU countries	13.6	23.1	70

* Top 500 global Fortune companies
Source : Meyer-Krahmer and Reger (1999)

In the context of globalization, foreign R&D has been increasingly necessary to support the expansion of international production. Besides, some of the traditional arguments for R&D centralization by the main centers of the parent company have become less compelling. This is the case for the cost of international technology transfer and the hypothesis that foreign countries lack the right human resources and scientific infrastructures. However, the argument of economies of scale and synergies remains by and large. The strongest determinants of the growing internationalization of R&D are probably to be found in the increasing need to de-centralize R&D. The sheer development of foreign production has already been mentioned. So has the increasing diversity of countries in which multinationals operate. These may be considered as demand factors for foreign R&D. Supply factors also play a role as foreign units may provide specific contributions to multinationals' global R&D capability.[9]

Firstly, as they have extended and diversified their foreign operations, the largest multinationals have progressively set up global R&D networks (Bartlett and Ghoshal 1989). The objectives are to rationalize R&D activities, to prevent duplications, but also to have each location specialize according to its potential contribution. The latter may come from the fact that a particular country represents a leading market (Meyer-Krahmer and Reger 1999). In the case of IT, the leading market is often the United States; for mobile telecommunications it is rather Europe, while Japan has been a first mover mobile internet access and services. A second, emerging, motivation for conducting foreign R&D is to source scientific and technological capabilities from countries which have developed an edge in specific areas. As a consequence,

[9] On the motivations and organization of global R&D networks. For such a perspective and typologies of R&D internationalization, see (Archibugi and Michie 1997, Gerybadze and Reger 1999, Zander 1999).

foreign R&D units now have more diverse functions. A large majority of foreign R&D units are design and development centers are *Home Base Exploiting*[10]. The number of *Home Base Augmenting* units tends however to increase (Sachwald 2000a).

1.2 The American business ecology and innovation based competition

American companies have proved very successful in ICT since the 1980s. This remarkable evolution is due to the adaptation of the American business environment to the new emerging technologies and market opportunities.[11]

American leadership in ICT

During the 1980s, American industry suffered from weak competitiveness in a number of mass production sectors such as the automobile, but US firms were also successfully challenged in high tech sectors such as semiconductors.[12] Since the 1990s, the picture has dramatically changed. In particular, American firms have taken the leadership in ICT, while European and Japanese competitors successfully defend strong positions on only a few segments.

One major source of American competitiveness is research and technological excellence. Table 3 underscores the technological strength of the US in information technologies. The indicator does not only take the number of patents into account, but also their quality as it is reflected by quotes from other patents. European positions are particularly weak.[13] Beyond the confirmation of the strong American positions in IT, table 3 shows that they have become much stronger during the 1990s, in contrast with the 1980s. Moreover, automotive technologies exhibit a similar and more surprising pattern. In health related technologies, American strength was substantially reinforced in the 1990s.

Table 3. Indicator of technological strength[1], by inventing country and technological field

[10] The distinction between the foreign R&D units exploiting the parent company's base and those aimed at augmenting it has been used in empirical studies by Kuemmerle (1997, 1999).
[11] This advantage has also proved very important in biotechnology.
[12] For an influencial account of this trend and a diagnosis, see (Dertouzos *et al*. 1989).
[13] Which is partly due to the fact that telecommunication patents are not included; Dalum *et al*. (1999) provide complementary data based on all patents in ICT.

	Automobile			Health			Information technologies[2]		
Country	1982-86	1987-91	1992-96	1982-86	1987-91	1992-96	1982-86	1987-91	1992-96
EU	1721	2880	2348	2376	3263	3373	4452	6304	5734
US	2665	4658	6748	5806	9339	12246	24424	34583	59791
Japan	3190	6494	3860	1512	1807	1624	12832	26419	34272
US/EU	1.55	1.62	2.87	2.44	2.86	3.63	5.49	5.48	10.43
US/Japan	0.83	0.72	1.75	3.84	5.17	7.54	1.90	1.31	1.74

1. Number of patents multiplied by the impact indicator (which is based on quotes by other patents).
2. Digital, optical and analog computing hardware and software (including cryptography, voice and image recognition and processing, and data storage), and semiconductor manufacturing and applications. Communications patents are not included.

Source : Based on (Albert 1998)

These statistical indications correspond with the results of sectoral and case studies which suggest that technological performance has been a major determinant underlying American resurgence since the 90s. But technological performance is only one determinant. "*American industrial resurgence*" actually rests on improvements in innovative performance in a broad sense, including "*the adoption and effective deployment of new technology as well as its creation*" (Mowery 1999: 4). The adoption of new information technologies in sectors such as the automobile, banking or apparel has required far-reaching organizational changes which have been necessary complements to investments in ICTs.[14] In turn, these evolutions have been secured by the strong competitive pressures experienced since the 80s. Despite the more crucial role of technological performance in IT, the American success stories in these high tech sectors actually rest on similar dynamics. Indeed, as argued above, innovation based competition is a particularly apt description of competition in high tech and thus firms in these sectors are most pressed to innovate constantly and to shorten time to market. American business ecology has been particularly favorable to competitiveness in IT because competition in the United States, including from foreign firms and start ups, fostered firms' responsiveness to both technological and manufacturing evolutions

The first fundamental point is the increasing role of interactions with users and suppliers in the process of innovation. These interactions result in particular from the disintegration of value chains mentioned above. In a number of sectors, such as computing, the latter is rooted in the maturation of products and technologies. Each major innovation in computer products, and especially the diffusion of micro computer since the 1980s, has led to more open systems and standards, allowing for the entry of new actors, focusing on part of the systems, such as hardware, software or specific components. In all high tech fields, customers and suppliers play

[14] On the interactions between work practices and investment in ICT, see in particular (Askenazy 2001).

an important role in shaping firms' assumptions about how their industry will evolve. In IT, as each segment became more focused, these interactions became more crucial. As a consequence, responsiveness to them constitutes a competitive asset for firms. More exactly, it is a competence which firms have to nurture. In hard disk drives (HDD), the computer manufacturers which have taken the risk to sell their devices to competitors instead of keeping them for internal consumption have actually better resisted to technological progress and entry by new competitors. In this case, Japanese incumbents have embraced the OEM[15] policy more consistently than American incumbents, which have been to a large extent displaced by new entrants (Chesbrough 1998). Generally, in IT, American firms have benefited from their demanding relationship with their sophisticated clients, in software and semiconductors for example. Conversely, the weakness of the Japanese software industry is related to vertical integration of major computer firms (Anchordoguy 2000).

HDD illustrates a second important determinant of competitiveness in ICT: manufacturing excellence. Indeed, innovativeness may be fundamental in high tech, but high quality and low cost are nevertheless crucial in a number of segments where competition is tough. In HDD, American producers have been able to maintain their very strong positions[16] and to withstand Japanese competition, including on the low-margin high-volume segments, thanks to manufacturing performance. Since the 80s, a number of American incumbents have been displaced by start ups which have been more dynamic at seizing opportunities. In 1982-83 some of these independent companies, like Seagate, started to move assembly to low-wage locations, starting with Singapore (McKendrick 1999). This move was very successful and was imitated by American competitors. On the contrary, Japanese firms have been slow to go offshore. As a result, American firms were able to organize efficiently international coordination and production. Better manufacturing performance has also been a determinant of the American revival in semiconductors,[17] even though innovation has played more of a distinctive asset in that sector (Macher *et al*. 1998).

The third important characteristic of the American system is its ability to generate successful start ups. It has often been underscored as a major factor of sustained competitiveness in high

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[15] Original Equipment Manufacture.
[16] Throughout the 80s and 90s, American firms have controlled more than 80% of the world market (Chesbrough 1998).
[17] US worldwide semiconductor market share fell from more than 60% in 1980 to a less than 40% in 1988-89, before reaching 50% in 1997. Between 1989 and 1997, Japanese share fell from 50% to about 30%. Throughout the period European share was around 10%.

tech sectors. Start ups have been useful in bringing new ideas and competences to ICT sectors. In particular, they enabled young graduates to enter the business with new ideas, or employees from incumbents to try their own business models. Finally, these entries have presented incumbents with challengers; incumbents either had to adapt or exited. This pattern has been observed time and again, especially when technologies experienced leaps, as with different generations in HDD and semiconductors, or with the creation of new market segments in computing.

Why did American companies restructure their production processes and learned new manufacturing methods ? Why were they particularly receptive to users' needs ? Why is the rate of birth of start ups particularly high in the United States? The underlying characteristics explaining these specificities are all related to the business ecology of the US, and in particular to dynamic competition on both product and factor markets.

Case studies of IT sectors emphasize the role of strong competition in promoting innovation. Competition among incumbents, but even more importantly for the dynamics of innovation, competition from start ups, has constituted a major characteristic of the American business ecology. Competition also played a stimulus role in users' industries, where firms have been compelled to adopt new technologies to respond to competitive pressures, which often implied extensive reorganization.[18]

The factors explaining the very dynamic trend of start up creation are quite complex, relating to various aspects of the American business ecology. The availability of venture capital, and more generally, a deep and flexible capital market have played an important role.[19] Venture capital is particularly developed in clusters where the rate of birth of start up is the higher, like Silicon Valley (Kenney 2000). Sectoral studies of IT also stress the importance for new firms to be able to attract talent, including from universities and incumbent firms.[20] This ability itself depends on characteristics of the labor market, but also of the capital market, as just mentioned, and, of the intense interactions between the business world and universities.

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[18] Both within firms (Askenazy 2001, Cohen *et al*. 2000) and at industry level through mergers and acquisitions in particular (Jensen 1993, Sachwald 2000b).

[19] Besides case studies and cluster studies, Kortum and Lerner (forthcoming) have found on a cross industry study that increases in venture capital activity are associated with significantly higher patenting rates.

[20] And from around the world. Graduates from Asian origin have been particularly active in Silicon Valley for example, both as engineers and as entrepreneurs (Kogut 2001).

To summarize, two major characteristics have been fundamental in fostering the impressive success of US firms in ICT. Firstly the existence of a rich pool of frontier knowledge and talented researchers and secondly, the ability of the American system to harness these resources to innovation in ICT. This ability is one feature of the American innovation system, but the analysis above suggests that the successful process depends more broadly on the business environment in which that system is embedded. The sustained flow of start ups which have been so important at nurturing a thriving IT sector in the US is indeed very much dependent upon the characteristics of the financial markets and upon the style of competition on product and service markets. Next section shows that public policies have been reinforcing these favorable characteristics of the American business ecology.

US policies in favor of ICT

Since the 1980s, US policies have actively supported two major pillars of the American innovation system, namely basic research and the circulation between the academic and the business world. The third important policy element, competition policy aimed at assuring the mobility of rents, represents an application of a deeply rooted tradition to the contemporary context.

A major role is traditionally attributed to public R&D funding in securing long term success in high tech. Numerous studies emphasize this role for public policies, both in ICT and in biotechnology. The specific channel of military R&D spending is widely acknowledged in the case of ICT. It has played a fundamental role for major innovations, from semiconductors to computers and Internet.[21] Since the 70s, this channel has lost part of its importance though; as Defense budgets have decreased and technologies have matured, civilian markets have become the target of innovation. The sheer size of civilian markets in IT have set off an increasingly market driven innovation dynamics.[22] Even in the case of Internet, the role of military funding goes quite far back in history. ARPANET started in 1969 as a DARPA project. The National Science Foundation became involved and the network became one of scientific researchers, before being privatized and open for business during the second half of the 1990s.

Reduced military R&D spending has lowered the share of public funding to industry

[21] On this theme for different innovations, see (Alic *et al*. 1992, Langlois and Steinmueller 1999, Bresnahan and Malerba 1999, Castell 2000).
[22] This is one major reason why the « spinoff paradigm » is not a relevant represenation of the role of

research by the US government since the 1980s. Public funding remains nevertheless very important to support excellent basic research and universities play a central role in the innovation process.[23] This is particularly important as firms have been reducing their budgets in basic R&D (Mowery 1998, Branscomb and Keller 1999). In recent years, the evolution of public R&D spending, important as it is, actually seems to have been relatively less important for the promotion of new technologies relative to the evolution of the broader technological and regulatory context, which has tended to promote the "privatization" of R&D results (Muldur 1997, Mowery 1998).

Since the 1980s, the scope and efficiency of intellectual property rights protection has been increased. Courts have reinforced the protection provided by patents. Moreover, the Bayh-Dole Patent and Trademark Amendments Act of 1980 allows inventors to file for patents on the results of research funded by federal funds. Inventors are also allowed to grant licenses for these patents. This legislation has triggered considerable growth in university patent licensing.[24] Better property rights protection has constituted an incentive to innovate and seek commercial applications for new technologies. American policies have paid much attention to this type of incentives. The growing role of protection for intellectual property in the innovation dynamics is one explanation for the insistence of US authorities to reinforce protection at the international level (TRIPs).

American policies have allowed firms and individuals to reap rents from invention, but have also been vigilant to ensure that firms remain exposed to competitive pressure. The role of the 1984 break up of ATT under anti-trust pressure in the expansion of telecommunication and the emergence of Internet has been extensively underscored (Bomsel and Le Blanc 2000, Catinat 1999). Back in 1956, anti-trust investigation had already prevented ATT from entering the commercial market for semiconductors and played an important role in the decision of the Bell Laboratories to license the original transistor and related patents (Macher *et al.* 1999).

Antitrust action has also worked at controlling the market power of IBM. Historically, IBM has enjoyed a formidable first mover advantage which the firm has strengthened with

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military R&D anymore (Alic *et al.* 1992, Sachwald 1999).

[23] Which is not contradictory with the tighter relationships between academic research and commercial applications (Larédo 2000, Pavitt 2000).

[24] In the same spirit, the Federal Technology Transfer Act (1986 and 1989) has allowed federal laboratories to cooperate with private firms through Cooperative Research and Development Agreements (CRADA) which usually include intellectual property provisions. Empirical research is being conducted on

Chandlerian three-pronged investments in technology, management and marketing (Bresnahan and Malerba 1999). As a result, by the early 1960s, IBM had achieved world dominance in mainframe. US policy was careful not to reinforce this monopoly situation. The US government procurement policy was open to diverse firms and fostered IBM competitors, both in hardware and software (Bresnahan and Malerba 1999, Mowery 1999a). IBM has also been under close scrutiny from antitrust as soon as it started to emerge as the dominant firm in the 1950s, which has resulted in the firm abandoning some anticompetitive practices. In 1968, IBM, which was threatened of antitrust prosecution, unbundled its hardware and software.[25] This action opened opportunities for the entry of independent software vendors (Mowery 1999a). IBM's unbundling also opened opportunities to Japanese competitors like Hitachi and Fujitsu which chose an IBM-compatible strategy and partly copied Big Blue's software (Anchordoguy 2000). In the 1960s and 1970s, US antitrust policy has thus worked at preventing IBM from cementing a dominant position as both a supplier of hardware and software. From the 1980s on, mini- and then micro-computers have been changing the general outlook of the competitive field, including the barriers to entry which had been protecting IBM.

In the 1990s, Microsoft position was not unlike IBM dominant situation back in the 60s. The investigation by the Department of Justice also presents similarities with IBM case and underscores the fundamental role attributed to competition in the American business culture (Dumez 2000). One major issue is that of bundling and the possibility of extending dominance from one segment to another. From this perspective, antitrust action is trying to foster innovation through entry and competition. As the debates surrounding Microsoft's investigation suggest, such an endeavor is quite challenging.

Tough antitrust policy was not always considered a positive aspect of the US business environment. In the late 1970s, antitrust policy was criticized for discouraging R&D cooperations and during the 1980s, lack of cooperation among US firms was considered as one of the weaknesses of the system (Dertouzos *et al.* 1989). The competitive crisis in a number of US industries, including semiconductors, has contributed to a far-reaching shift in antitrust policy enforcement. The 1984 National Cooperative Research Act (NCRA) has been a major result of these debates. The NCRA, which has been amended in 1993, was aimed at fostering the formation of industry-wide R&D collaborations. SEMATECH consortium, which was formed to

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the quality of patents, which may have decreased (Pavitt 2000).

[25] IBM started to supply and price separately software and services from hardware.

develop semiconductor manufacturing technology[26], is the best known of these collaborative organizations. Studies of the effects of SEMATECH as well as larger evaluations of the cooperations under the NCRA suggest that they have often been aimed at pre-competitive research and at enhancing vertical interactions among numerous participants.[27] As a result, they do not seem to have constituted threats to the competitive process.

Trade policy has played a complementary role in stimulating competition in IT on the US market. The relatively liberal policy towards imports of hardware and components has favored decreasing prices and the diffusion of computing. As in the case of Internet, higher prices in Europe and Japan partly explain lower equipment rates.[28] In turn, a larger market has stimulated both hardware and software supply. Conversely, protection of the US semiconductor market from Japanese competition at the end of the 80s has had a number of perverse effects. American production of DRAMs had already largely disappeared, while computer manufacturers had to suffer higher prices. At the same time, higher international prices fostered new entry by the Korean suppliers.

The US innovation system and business ecology thus have been particularly adapted to the emergence of innovation based competition and the formidable development of ICT in the 1990s. This does not mean that the US innovation system is perfect, nor that the American first mover advantage is easily sustainable. These aspects will taken up in the general conclusion. Part two below first deals with the reactions of European firms and policies.

2. European responses

Since the 1980s, the American innovation system exerts a strong attraction on both European firms and individual researchers. This is the case in particular in ICT. A number of European entrepreneurs have also chosen to create new technology based firms in the United States. European governments have progressively extended their response from innovation

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[26] The SEmiconductor MAnufacturing TECHnology consortium was created in 1987 with both industry and federal government funding. The latter was terminated in 1996 and SEMATECH has been developing much as an industry association, largely focusing on the diffusion of information and best practice techniques (Macher *et al*. 1999).

[27] Evaluations have largely been conducted through case studies, which suggest that efficiency gains have come from reduced duplication in particular (Vonortas 1997, Hagedoorn *et al*. 2000)

[28] In 1997, there were 50 installed PC for 100 inhabitants in the US, 23 in the UK, 20 in Japan and 18 in France. The rate of growth between 1992 and 1997 has also been higher for the US (OECD 2000).

policy to wider policies to adapt their respective national business ecology. The EU technological policy has also been progressively reconsidered.

2.1 European firms' strategies.

In his study of the reaction of European firms to the first American challenge, John Cantwell (1989) suggested that their successful response was mainly based on their reviving their indigenous technological capabilities after World War II. Viewed from his perspective, the main contribution of the wave of American investment in the 50s and 60s may have been to provide a competitive spur to European firms. The American competitive threat also constituted an incentive to adopt the organizational innovations which US groups had pioneered before WWII and which spread throughout Europe after the war (Kogut and Parkinson 1993). During the 1960s and 70s, a number of European countries did enter a catching up process, which has been quite clear in a number of scale intensive manufacturing sectors (Fagerberg *et al.* 1999). In the 90s, European large firms have developed into multinationals of their own and are integrated into global networks, which enable them to try to reach out to the U.S. system of innovation.

European R&D units in the United States

Over the past decade, foreign firms have substantially increased the number of laboratories they control in the US. In 1994, Dalton and Serapio (1995) counted 645 foreign-owned R&D facilities and 715 in 1999 (Dalton and Serapio 1999). Japanese firms owned 251 as against 382 for the European countries.

European-owned R&D units often aim at exploiting the home base technological capabilities. However, many are concentrated in high-tech sectors where the US has a lead. In the case of drugs, for example, a large proportion of the European R&D units focus on biotechnology. This is the case with all the 7 French R&D units in pharmaceuticals, with 17 out of 26 for the German ones and with 11 out of 15 of the Swiss ones. With British firms, which benefit from a stronger domestic environment in biotechnology, only 7 of their 15 pharmaceutical R&D units focus on biotech.[29] Most of these European labs seem to aim at technology sourcing, including establishing relationships with the American scientific community (Florida 1997). Conversely, US-owned R&D pharmaceutical units located in European countries are few and none focuses on biotechnology.

In television, comparative advantage has largely shifted to Asia, but Japanese and Korean companies have 11 R&D units in the US, all of which focus on HDTV and multimedia devices. Only Thomson has R&D units dedicated to TV among European companies; these two units focus on digital television and HDTV transmission. In ICT, European firms also establish R&D units in the Silicon Valley. This is even the case for the very successful Nokia.

Acquisitions of American high tech companies

In the context of innovation-based growth, firms feel pressured to "out-innovate the innovators" (Hamel 1999). In a number of cases, this means plugging in complementary resources to fill "capability gaps" very quickly so that internal developments are precluded (Chaudhuri and Tabrizi 1999). As a consequence, acquisitions have become very numerous in high tech sectors.

The American market is very active, with both local and foreign firms buying start-ups as well as larger high-tech targets. Acquisitions have had a large impact on R&D spending by foreign companies in the US as they have included important operations in high-tech sectors (Dalton and Serapio 1999). During the 1990s, the most important ones were initially in pharmaceuticals and biotech but began to shift to information technology and telecommunications by the end of the decade. For example, Alcatel has bought up a number of young American companies to fill its capability gap in Internet technologies.[30] Siemens and Ericsson have also bought American firms to prepare the third generation of mobile phones which will include Internet access.

Transatlantic and European cooperative agreements

Since the 1980s, firms have actively resorted to cooperative agreements as an organizational response to more complex and demanding competitive environments and in particular to innovation based competition.

Table 4 suggests that European firms primarily choose American partners for their technological alliances. This tendency is particularly strong in pharmaceuticals and computers. Moreover, in the case of computers, intra-European alliances are very few because European

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[29] These details are drawn from lists in (Dalton and Serapio 1999).
[30] In 1998-99, Alcatel earmarked $16 bn for such acquisitions, including (in $ bn) : Newbridge (7), DSC (4),

firms also team up with Japanese partners.

Table 4. Geographical distribution of international technological alliances by European firms, %*, 1984-95

	Transatlantic	Intra-Europe
Pharmaceuticals	72.4	13.7
Computers	64.0	9.3
Electronics	52.4	22.0
Instruments	58.2	22.4
Electric equipment	55.9	17.6
Chemicals	44.9	21.4
Automobile	37.5	30.5
Aerospace	21.7	37.5

* National alliances are excluded. The calculation takes into account both the number of alliances and the number of participants involved (more than 2 in 20% of the cases).

Source : Calculation from IFR/SDC data base quoted in (EC 1997)

The case of the electronic sector and information technologies is particularly interesting to analyze for several reasons. Firstly, because intra-European alliances represent such a small share of technological alliances, while European governments and the EU have devoted a substantial share of their innovation policy funds to support intra-regional cooperative R&D in these areas. Secondly, because data is richer on electronics and information technologies so that detailed observations are available.

European innovation policies began to support intra-European cooperative R&D at the beginning of the 1980s. This approach was extended during the second half of the decade, while the Single Market program was being implemented. Accordingly, it is interesting to go back to this period, during which the number of intra-European mergers, acquisitions, joint ventures and alliances increased substantially.[31] Table 5, which compares intra-European alliances with transatlantic ones and does not include domestic alliances, suggests that transatlantic alliances play a fundamental role.

Firstly, transatlantic alliances outnumber intra-European ones except for R&D alliances in microelectronics at the end of the 1980s, that is, when European policy very actively sponsored important cooperative agreements in this area (Hobday 1995). Secondly, the ratio of European to transatlantic alliances is particularly low for computers and was decreasing at the end of the 1980s, both for R&D and for market-oriented cooperation. In telecommunications, on the

Xylan (2), Genesys (1 .5), Assured Access Technologies (0.35) and Internet Devices (0.18).

[31] The Commission has underscored this trend, but did not deal with the simultaneous globalization strategies of European firms which involved transatlantic alliances and M&As (Sachwald 1994).

contrary, European R&D alliances became relatively more frequent at the end of the 1980s.

Table 5. Intra-European vs. transatlantic technological alliances in the 1980s

	Ratio of intra-European to Transatlantic alliances	
	1980-1984	1985-1989
Total		
R&D-only alliances*	0.81	0.77
Market-oriented alliances*	0.52	0.54
Information technology total		
R&D-only alliances	0.65	0.88
Computers		
R&D-only alliances	0.33	0.25
Microelectronics		
R&D-only alliances	0.50	1.44
Telecommunications		
R&D-only alliances	0.35	0.88

* In the CATI data base, strategic technology alliances are divided into alliances that are primarily related to R&D and those for which market access is more important.

Source : calculations from (Duysters, Hagedoorn 1996)

Table 6, which is based on more recent data, provides a similar picture, namely, that transatlantic technological alliances are predominant in sectors where European firms are in a relatively weak competitive position. In semiconductors, US-Japanese alliances constitute the largest category of international alliances, but transatlantic alliances are still three times as frequent as intra-European ones. In computers, transatlantic alliances are also three times as frequent as European ones and constitute the largest category of international alliances. In telecommunications, on the contrary, intra-European alliances are as frequent as transatlantic ones.

Table 6. Geographical distribution of technological alliances in information and telecommunication technologies (ITT), 1988-97, %

	US domestic	Transatlantic	Intra-European	US/ Japan
ITT all[1]	19	21	16	14
Telecommunications	11	24	25	6
Semiconductors	n.a	15	5	27
Computers	31	22	7	17

1. Including along with the three sectors in the table: software, defense electronics, automobile electronics and consumer electronics. The three sectors in the table represent 73% of the total number of recorded technological alliances.

n.a Details are not available, but the share of domestic US alliances is probably substantial.

Source : Data from the data base DATI maintained by Aziz Mouline. For complementary data, (Mouline 1999).

Two main conclusions may be drawn from the above data on cooperative agreements. Firstly, European firms have teamed up with American partners and, to a lesser extent, Japanese ones, in areas of technological weakness.[32] In telecommunications, where they have stronger competitive assets, they tend to follow a more intra-European pattern of alliances. Secondly, European policy seems to have increased the propensity to engage in intra-European cooperation during the second half of the 1980s. This pattern seems, however, to have waned during the 1990s.

Differences in national systems of innovation and specific firms' technological trajectories go a long way towards explaining the choice of extra-EU partners by European firms in their catching-up strategies since the late 1980s. European pharmaceutical groups have teamed up with American partners in biotechnology (Sharp *et al*. 1994), while European firms have entered into various types of alliances with both American and Japanese companies in information technologies (Hobday 1994, Mouline 1999). The attraction of different innovation systems may however, be offset by other factors. Firstly, cooperation with companies from distant countries tends to be more costly than cooperation with closer partners. Secondly, public funding may influence the choice of partners. Since the late 1980s, cooperative R&D has been promoted as part of innovation policies on the basis of knowledge spillovers and economies of scale in R&D. EU innovation policy has mainly relied on the promotion of cooperative R&D among European firms, which constitutes an incentive to choose European partners. Likewise, relationships with local universities or public research constitute another incentive to enter into local cooperation agreements.[33] Besides, public funding and research projects on generic subjects may greatly alleviate the risks involved in cooperating with close competitors. As a consequence, R&D cooperation aimed at pooling similar resources between firms from a same country or zone is much more likely for generic and publicly funded research.

A French survey on patterns of R&D cooperation in the mid-90s confirms both the higher propensity to ally with close partners and the technology sourcing motive in the case of partnerships with American or Japanese firms (Miotti and Sachwald 2000). Domestic and EU cooperations are more frequent, but also less ambitious and tend to be less productive in terms of innovations.[34]

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[32] This same conclusion had been underscored by Veugelers (1995) in an earlier study.
[33] In this case, a firm would cooperate with public institutions, but in a number of European projects, firms participate in large research programs involving both public and private participants.
[34] Cooperative R&D supported by the EU does not seem to increase patenting by firms, while other types of cooperation do (Giarratana and Torrisi 2000).

2.2 European policies

Innovation policies and the European business ecology

Since the 1980s, innovation policies have been adapted in order to correspond better to the evolution of the innovation process which has been briefly described in section 1 above. In particular, policy makers have progressively recognized that the process was not a linear one, from science to new products, but an interactive one between various types of actors. As mentioned above, in such a process demand plays a relatively more important role. Besides, recent analyses emphasize the role of diffusion as one crucial element of the innovation process itself. These results have contributed to the recognition of the role of the more general national environment on innovation and diffusion processes and to the broadening of the scope for policy making. *Narrow* or traditional innovation policies, which focused on the supply of science and technological resources, have thus become part of wider perspectives, which pay much more attention to environmental conditions, including macroeconomic and structural factors. Reforms have thus been directed at both maximizing the efficiency of innovation policies and at improving the framework of institutions and connections that firms use to innovate and absorb technology. Table 8 summarizes the main relevant structural factors - besides the broad characteristics of science and technology structures. The latter do remain fundamental in the process. In the case of ICT, European countries have lower performances than the United States – as measured by publications in particular (Pavitt 2000a). The above analysis of the determinants of success in IT (section 1) nevertheless suggests that structural characteristics of products and factor markets play an important role. In Europe, these characteristics strongly interact with the evolution of national innovation systems.

Table 8. Structural framework conditions for innovation and technology diffusion: Strengths and weaknesses in OECD countries in the 90s

	United States	Continental Europe	East Asia
Product markets	**. Regulation, competition policy** **. Abundant information on products, suppliers and customers**	. Regulation, competition policy* . Abundant information on products, suppliers and customers	. Regulation, competition policy . Abundant information on products, suppliers and customers
Financial Markets	**. Competition in financial intermediation** **. Role of active investors, venture capital** **. Exposure of corporations to capital market scrutiny**	. *Competition in financial intermediation* . *Role of active investors, venture capital* . Exposure of corporations to capital market scrutiny	. Competition in financial intermediation . Role of active investors, venture capital . Exposure of corporations to capital market scrutiny
Labor markets	**. High labor market mobility and flexibility** . Business culture – internal incentives for human resource development	. High labor-market mobility and flexibility . *Business culture – internal incentives for human resource development*	. High labor-market mobility and flexibility **. Business culture – internal incentives for human resource development**
Social cohesion	. Equality . Broad-based upskilling	**. Equality** **. Broad-based upskilling**	**. Equality** **. Broad-based upskilling**
Business networks	. Culture of co-operation . Venues for partnering **. Information on potential partners**	. *Culture of co-operation* **. Venues for partnering** . Information on potential partners	**. Culture of co-operation** **. Venues for partnering** . Information on potential partners
Government charges	**. Business taxes, other charges and compliance costs**	. Business taxes, other charges and compliance costs	. Business taxes, other charges and compliance costs
S&T structures	**. Basic research** **. Technical and industrial research** . *Active science-industry interface*	**. Basic research** . Technical and industrial research . Active science-industry interface	. Basic research **. Technical and industrial research** . Active science-industry interface

Key: **Strength,** *Neutral,* Weakness.

** On competition policy in Europe, see the remarks below though as this is a summary and may not take into account the recent trend, especially a the EU level.*
Source: Adapted from (OECD 1998)

Weak science-industry interface has been one major area for policy reform in Europe as it is considered to be one determinant of the European paradox. In this perspective, France for example has taken steps to promote enterpreneurship among researchers. Success does not only depend on devising appropriate incentives for researchers and modifying career paths, but also on the prospective rate of success of new technology based firms (NTBFs). This is where structural characteristics of European economies come into play. A number of structural features of product and financial markets generate higher barriers to entry by NTBFs. The lack of entrepreneurial culture is often mentioned as a major explanation for the scarcity of NTBFs in Europe relative to the U.S, which translates into the scarcity of new successful firms in high tech.[35] Entrepreneurial culture is rooted in education, which means that policies can act upon it, but only in the long term. The willingness to venture into creating a new and risky business however also depends on the height of both incentives and obstacles. European policies have been addressing both recently and the extension of opportunities have stimulated entrepreneurship, but this aspect remains a problem according to those most involved in capital venture and the promotion of NTBFs.

The lack of venture capital for NTBFs has been largely debated in the 90s and European countries have deployed substantial efforts to promote this source of funding for new firms. France and Germany have been particularly active on this front over the last couple of years.[36] The experience of both countries illustrates the interdependence of different types of measures as the availability of funds has proved to be only one of the necessary elements. Valuable projects must exist, which depends both on researchers willing to venture out of their labs and experienced managers willing to venture out of large firms. Venture capitalists also need to work in a favorable overall financial context, including appropriate exit mechanisms. Hence the importance of developing further the second-tier stock markets such as the *Second marché* in France or the *Neue Markt* in Germany.[37] In this context, the promotion of venture capital has triggered debates on the role of pension funds or the fiscal treatment of stock options which NTBFs might offer to attract talent.

Financial market reforms illustrate the systemic interdependence and the difficulty of

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[35] For comparative data over a long period, see (Cohen and Lorenzi 2000).
[36] British financial markets were already better equiped and venture capital is more developed in the UK. In 1999 venture capital funding for high tech firms as a share of GDP is highest in Europe in Belgium, the Netherlands and Sweden (EC 2000).
[37] Which remain much smaller than the NASDAQ (Catinat 2001).

adapting European economies to innovation based competition. The low rate of birth of NTBFs may be even more deeply rooted in European business ecology as the scarcity of start-ups is tightly related to the protection of incumbents from competition.[38] What could be called an *incumbent paradigm* is related to historical and geographical patterns, such as the specialization of countries in chemicals and mechanical industries or the fragmentation of the European economic space. German leadership in chemicals for example has been rooted in investments in R&D dating back to the early XXth century; stability in the technological paradigm and economies of scale have then helped sustaining competitive advantage for decades. The effect of fragmented European markets has long been compounded with support of national champions to protect incumbents. The national champion approach has been progressively abandoned since the 1980s, including in France where it has been widely supported and where it yielded some remarkable technical successes.[39] Its effects are however long lasting. In France for example, a large share of industrial R&D in ICT remains localized in large vertical structures (Majoie 1999).

The sectoral studies above suggest that the scarcity of new entrants and the lack of success by diversified incumbent groups is one explanatory factor for European failures in IT. In the variegated Internet related activities, new European firms are still much less numerous than American start ups. In a number of cases, new entrants are actually established groups which try to turn themselves into new, high tech firms. Mannesmann or Vivendi for example. Others, as illustrated above with the case of Alcatel, are sticking to their activity and plug into the American system to acquire the required competences in Internet technologies. Some of these strategies may succeed, but Europe does need more NTBFs to compete in highly specialized new fields where innovation is based on multiple contributions in various areas and where commercial perspectives are too modest to interest large corporations. Small firms are more liable to be responsive to demand by customers and are thus a fundamental element of dynamism in the present context, as suggested in section 1.

Entry by NTBFs should be stimulated by the increasingly competitive environment within the EU. Competition is being stimulated as the result of both national deregulation and pro-competitive policies as well as tighter European integration - for which the EU competition policy

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[38] From this point of view, there is a parallel to be made with Japan ; see for example (Anchordoguy 2000, Murakami 2000).

[39] On the French evolution, see Cohen (1992, 1996), Mustar (1994), Boyer and Didier (1999).

plays a role.[40] From this point of view it seems that the single currency is boosting the effects of the Single market and that more integrated European markets constitute one incentive for pan-European M&As. European policies thus contribute to the promotion of innovation as they influence the business ecology throughout the Union. The EU has nevertheless targeted some policies at the promotion of innovation and at ICT more precisely.

EU policies for the information society

The European Commission has been proposing measures to promote information society since the early 1990s. Michel Catinat (1999) actually argues that the Commission has been insightful and has provided a similar package of policies as the United-States, namely the combination of deregulation in telecommunications and technological policy. One major problem here is that EU policies and decisions are not always efficient at changing national policies or structures. From this point of view, it is no surprise that deregulation has had greater effects than the EU innovation policy. Indeed, the first one requires member States to incorporate European directives into national law, however reluctantly, while the second is bound to have a quite marginal effect on national systems and policies.

Opening European telecommunication markets to competition has required both harmonization among national technical standards and deregulation. Both policies have been conducted since the mid-80s. At first, some member countries were quite reluctant at deregulating telecommunications, but after they became convinced that lower prices would contribute to the diffusion of IT and to the emergence of information society, the process progressed more smoothly (Catinat 2000). The 1994 Telecommunication Council decided to complete the liberalization of both services and infrastructures markets by January 1998. Some States have applied the decisions more completely than others but the process of deregulation may be considered as quite satisfactory, even if during the 1990s, Europe probably lost some time over the US. A number of studies have indeed showed a quite clear negative relationship between the telecommunication prices and Internet diffusion (OECD 2000). From this perspective, the lower prices of computers and the diffusion of computer usage have to be mentioned as important factors in the US, which is consonant with the above argument on the role of the American business ecology (section 1). With respect to the current opening of

[40] The assessment on competition in table 8 is global, taking into account several European countries. EU competition policy may be considered tougher than what is implied by this table. Moreover, recent

competition on the local loop, unbundling has been decided both in the US and the EU. The EU acted on the local loop after the American Telecommunication Act of 1996, but the latter did meet with implementation problems (Bomsel and Le Blanc 2000, Catinat 2001).

The Commission has also provided a number of analyses of the innovation process and of the specific problems encountered by European countries. It has in particular underlined the systemic problems mentioned above.[41] The Commission can not however directly act on national systems of innovation. Besides, its technological policy only has very modest funds available. As a consequence, European innovation policy was bound to have limited effects on "the rate and direction of technical change in Europe".(Pavitt 1998). This argument may seem quite obvious since EU R&D budget represents a small share of member countries expenditure on R&D,[42] but it has long been overlooked. Actually, one major problem with EU innovation policy, and in particular with the Framework Programmes, is that too much has been expected from them.

The framework for EU innovation policy has been elaborated at the beginning of the 1980s, when public authorities sought means to fight eurosclerosis and the Japanese challenge. Intra-European consortia have been devised, based on the experience in information technologies and the ESPRIT program, as ways to close the technology gap and to catch up with American and Japanese competitors. Sectoral studies (Langlois and Steinmueller 1999) as well as more general analyses (Peterson and Sharp 1998) conclude that EU research consortia have only weakly contributed to this objective. These disappointing results are partly due to multiple objectives of the European cooperative schemes. Indeed, the European R&D programs also aimed at stimulating cooperation in Europe to create a pan-European community of researchers. Finally, European programs also aimed at promoting cohesion among the EU member countries. EU programs and EUREKA did succeed at creating European networks of researchers and greatly stimulated pan-European cooperation.[43] They also provided new opportunities to firms and research institutions of the cohesion countries (Sharp 1998). Catching-up with world best practice and frontier technologies may have been contradictory with these intra-European objectives though.

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evolution tends to be towards tougher policies in different countries.

[41] In the 1995 Green Paper on innovation (EC 1995); see also Caracostas 1998).

[42] About 5% of civil public R&D spending, after increases since the 1980s (EC 1997, EC 2000).

[43] This has been argued by numerous evaluations and studies on the Framework Programmes and EUREKA projects.

The experience of Japan and the US suggest a more general explanation for the modest results of research consortia. Indeed, a number of studies of publicly supported research consortia in both countries conclude that they are at best complementary to firms' own efforts at catching up, either through their own attempts at innovating or through increased productivity.[44] Because of appropriability and incentive issues, large publicly funded consortia are best suited to foster research dissemination and stimulate vertical collaboration.[45] This may be quite useful, as in the cases of the Japanese VLSI project or SEMATECH in the United States, but it is not sufficient to catch-up. Besides, national or EU consortia may prove much less useful in the context of global innovation-based competition where public institutions can not hope to nurture national champions in the most dynamic sectors, and in particular in IT. This is why the "ESPRIT model" (Peterson and Sharp 1998) based on the assumption that European former national champions had to be encouraged to cooperate and pool their resources appears much less relevant today. These basic design problems and this lack of relevance should be considered in the explanations for the progressive lower interest of large firms for EU programs, along with the explanations relating to the organization of the programs and to the process of selection of projects.[46]

Disappointing performances of EU innovation policy have triggered calls for reforms. One major problem has been that reform had to start with a new reflection on the objectives which a European innovation policy should foster.[47] On this issue, the acceleration of technological advances and the New American Challenge have certainly had a positive influence. The challenge has been a mighty incentive to give a fresh look at the policy which had been developed since the 80s. In January 2000, the Commission issued a Communication[48] as part of the preparation of the Lisbon summit which outlines new perspectives for the EU policy. Its contents suggests that the Commission has been drawing on the mixed assessments of the shared cost Framework programs as well as on the implications of the systemic analysis of innovation processes.

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[44] On Japanese consortia, see in particular (Sakakibara 1997); on SEMATECH (Mowery *et al.* 1998; Langlois and Steinmueller 1999) and on other US consortia (Branscomb and Keller 1999).
[45] Empirical studies suggest that consortia involving numerous firms, including rivals, tend to focus on this type of research and have often been supported by public funds (Sachwald 1990; Sakakibara 1997; Branscomb and Keller 2000). For a theoretical argument, see (Cassiman and Veugelers 1998).
[46] See for example (Guillaume 2000).
[47] For different points of view, see for example (Pavitt 1998, Cohen and Lorenzi 2000); Peterson and Sharp (1998) also present different positions and oppositions.
[48] *Towards a European research area* (EC 2000)

The Communication represents an effort to reflect on subsidiarity and on the overall objectives which a « *real European research policy* » (EC 2000 :7) should address. It suggests that the European level would be particularly relevant to strengthen basic research and research infrastructures. Europe should indeed be able to reap economies of scale in these areas (Soete 2000). From this perspective, the proposals emphasize the driving role of « *centers of excellence* » which should be better integrated on a continental scale, in particular through the use of new interactive communication tools. Moreover, these centers should be open both at the European and at the international level. European policies should focus on fostering a more favorable innovation environment, in particular with respect to venture capital and the patent system. On the issue of diffusion and knowledge transfer, the Commission suggests that further clarification between innovation policy and regional policy is necessary. As a general approach, the Commission proposes that evaluation and analysis of « best practices » should be much more systematically undertaken at the European level. Results and information would then be circulated as much as possible. Comparative studies of policies to identify « best practices » are on the rise as tools of policy analysis. OECD in particular has been practicing policy benchmarking extensively, to examine the issue of unemployment and job creation. It would certainly be useful to have in depth studies based on this approach at the European level on the various issues related to innovation.[49]

The proposals outlined by the Commission to create a real European research policy are quite ambitious. They represent a new step in European integration, which requires that governments acknowledge the relevance of such a European level policy <u>and</u> accept to revise their own policies at the national level. Persistent nationalism has been one problem in the functioning of the European Framework programs and the intergovernmental EUREKA scheme. The emerging new R&D paradigm discussed above as well as the perception of a new American challenge may have been necessary to foster radical change in attitudes.

[49] Table 8 above provides a very short summary from an OECD study.

Conclusions

At the end of the 1980s, serious concerns had been raised in the United States over the loss of industrial competitiveness, pinpointing at a number of perceived deficiencies in the prevaling American business ecology. Some of these same American features, such as the extensive role of financial markets in funding corporate investment, have turned into institutional assets in the new era of innovation based growth. On other aspects, such as poor manufacturing capabilities, American firms have learned from their competitors. Finally, public policies have taken steps to remedy some of the systemic weaknesses such as insufficient R&D cooperation between firms. Thriving ICT and their diffusion across sectors in the US can thus be explained both by traditional characteristics of the American system and by the co-evolution of this system with the requirements of innovation based competition.

This paper has further showed that European policies have endeavored to adapt national systems by introducing specific measures, some of which have been inspired by the American experience. Notwithstanding substantial differences between innovation and business systems across Europe, these reforms tend to be inspired by the American success story. A parallel may be drawn with the fascination which the Japanese system exerted during the 80s and which probably influenced policy steps in favor of cooperative research.[50]

A first major policy issue then is the extent to which convergence is desirable, or, alternatively, whether a number of isolated characteristics can be adopted.[51] The discussion of venture capital has suggested that such institutional cherry picking is quite difficult. Besides, the crucial role of competition in American business ecology is rooted in the American culture. While this paper has discussed different characteristics of the general environment and their influence on innovation in high tech, it has also echoed preoccupations with the level of basic research in ICT. As a consequence, national and EU policies should pay more attention and possibly devote more resource to academic research. This quantitative perspective should however not distract attention from the need for further institutional evolutions.

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[50] These cooperative efforts, even if they are backed by public funds, have proved inefficient though in areas such as software where the broader catch-up system was inadequate (Anchordoguy 2000).
[51] Complementarities between different features of national systems is becoming an important area for research (Kogut 2001).

A second set of issues concerns the sustainability of the current American success in innovation. Concerns have been raised by researchers about some evolutions, which may be welcome in the current context, but unsustainable, such as the reduction of basic research conducted by firms or the extension of the scope of patenting. Privatization of research results constitute entrepreneurial incentives, but may also generate long term perverse effects on the diffusion of innovation. In the case of Internet, the US government successfully combined two decades of public funded R&D activities with an array of direct and indirect policy mechanisms to stimulate commercial exploitation when computer networking matured. Such a success may be difficult to reproduce.

European reforms aimed at promoting the information society have thus to take a whole set of issues into account, and should certainly not engage in what would be “me too” policies. European authorities and the EU should rather devise policies better suited to their own trajectories. In the area of intellectual property rights for example, European researchers suggest a cautious attitude, while in the case of the protection of privacy, Europe has had an efficient approach, which has eventually led to an agreement with the US (Catinat 2001, Cowan and Paal 2000).[52] One challenge is to combine adaptation of individual country’s innovation capability with the design of a truly European policy in the relevant areas such as basic research, technology diffusion and human mobility. Such a policy should aim at reaping scale economies where they exist and enhance European research quality (Soete 2000). The existence of the Single market and related policies should contribute to this effort, as the unification of the American market has been an asset for technology diffusion since the XIXth century.

Finally, European countries may be able to benefit from their catching up position, as they did in the 60s and 70s. A number of indicators suggest that the catching up process is underway, even if Europe clearly still lags behind the United States with respect to the diffusion of ICT - except for the mobile phone. Keith Pavitt (1998) suggested that Europe was dynamically catching up with the US in the 60s, precisely when the first American challenge was being discussed. A similar phenomenon could be underway, and may accelerate as recent policy measures are fully implemented. It would however be unreasonable to expect Europe to follow exactly on the American evolution, if only because the starting point has been so different, both in terms of economic specialization (with very little IT hardware in particular) and in terms of institutions.

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