The Globalisation of Technology and the European Innovation System

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1. Introduction

The process of European integration is not based on a customs union, a common agricultural policy and a single currency only: it is also based on circulation of knowledge among individual member countries. This is not associated to cultural and social values only, but also to the belief that economic growth and welfare in the old continent is strictly associated to its capability to generate and diffuse new technologies. It is therefore not surprisinlgy that there is a major policy concern within governments, business and trade unions on the ways to promote scientific and technolgical activities and to foster innovation in firms.

The signals of a worsening of the European economy both in comparison to Japan and the USA are increasing (see Gambardella and Malerba, 1999; Fagerberg, Guerrieri and Verspagen, 1999; Vivarelli and Pianta, 2000), especially in the most dynamic sectors of the economy. It is more and more evident that Europe is not managing to keep on foot in the new economy based on the intensive use of ICTs. United States and Japan have proven to be much more vital in the rising fields and industries. While in the 1980s we assisted to the dramatic rise of Japan and other East Asian economies in hardware technologies linked to to ICT (for a comprehensive overview, see Freeman, 1987), in the 1990s the United States have managed to recover their traditional economic leadership in knowledge-intensive industries by exploiting and disseminating ICTs in the service sector. Within the triad, Japan and the other East Asian economy continue to have a prominent position in the generation of the 'hardware' component of ICTs, while the USA have a dominant position in the 'software' component. Europe has neither of them. It is therefore not surprising that a substantial and increasing part of the European Commission budget is devoted to promote scientific and technological advance.

In the knowledge generation process as in any other aspect of the economic and social life Europe is not separated by the rest on the world. The dissemination of new ideas, knowhow and technical expertise does not respect the frontiers of individual states nor the European borders. While Europe is adjusting with difficulties to the new technological landscape characterized by the so-called new economy (see Soete, 2000), the forces of the so-called globalisation have affected science and technology as any other side of human life. How will the dynamics of globalisation affect the European economy in the generation, transmission and dissemination of new knowledge? Are they allowing to bridge the existing gaps with the USA and Japan?

This paper discusses the following issues:

- To identify the various meanings of the so-called 'globalisation of technology';

- To report some empirical evidence on the various forms of the globalisation of technology;

- To explore to what extent and in which direction the globalisation of technology is affecting the European Union;

- To check if governmental science, technology and innovation policies undertaken by European national governments are adequate for this process;

- To assess the role of science, technology and innovation policies carried out at the European level for the benefit of European welfare, competitiveness and growth.

2. The meanings of globalisation of technology

Globalisation is one of the most widely used neologisms of this decade. It has been applied virtually to every aspect of human life (for an overview, see Held et al., 1999). A very large literature has been devoted to the globalisation of technology and this is hardly surprising (for overviews, see Lundvall and Borrás, 1997; Archibugi, Howells and Michie, 1999). On the one hand, new technologies are a fundamental vehicle for the transmission of information and knowledge across different regions. Without internet, satellites and new telecommunications it would not be possible to transfer information, at low or negligible costs, from one part of the world to another and this is the material condition which allows globalisation in aspects as different as finance, production, fashion, media and culture. On the other hand, the production and dissemination of inventions and innovations has become much more global in scope than in the past.

In the last years, we have attempted to distinguish different meanings of the globalisation of technology with a view to measure each of them quantitatively and to provide appropriate policy analysis on each dimension (see Archibugi and Michie, 1995; Archibugi and Iammarino, 1998; 1999). This taxonomy identifies three main categories:

a) the international exploitation of nationally-produced technology;
b) the global generation of innovations by multinational enterprises (MNEs); and
c) global technological collaborations.

The aim of this taxonomy is to classify individual innovations according to the main methods used to generate and exploit them. The categories are therefore not mutually exclusive at the firm level.[1] Enterprises, especially large ones, generate innovations following all the three procedures described. The three categories of this taxonomy are described in Table 1.

The first category includes the attempts of innovators to obtain economic advantages by exploiting their technological competences on markets other than the domestic one. We have preferred to label this category 'international' as opposed to 'global' since the innovation introduced preserve its own national identity, even when it is diffused and marketed in more than one country. Both large and small firms take part in this form of internationalisation, although large firms are generally better equipped to commercialize in foreign markets their innovative products.

The second category is represented by the global generation of innovations. It includes innovations generated by single proprietors on a global scale. Only innovations produced by MNEs fit into this category. The innovations in this category are not any longer generated in one single country; on the contrary, they receive inputs from different research and technical centres which belong to the same MNE. The bulk of MNEs is composed by large and often giant firms. For small firms it is very problematic to generate innovations globally.

[1] There is an additional category which should be added to this taxonomy, namely the innovations which are generated and used within the boundaries of a state. However, since this taxonomy is devoted to describe and interpret the globalisation of technology, innovations which do not cross borders are not considered.

Recently, another form of globalisation of innovative activities has asserted itself, midway - to a point - between the two categories described above. We have in fact witnessed a growing number of agreements between enterprises, often situated in two or more countries, to develop given technological inventions together (Mytelka, 1991; Dodgson, 1993). The need to cut the costs of innovation has created new forms of industrial organisation and new proprietary arrangements, which are now expanding beyond the technological sphere as such. Both small and large firms are active in this form of transmission of knowledge; in particular, small firms can use it as an alternative source to innovate preserving their ownership.

In reality, enterprises have imitated a method of generating and transmitting knowledge typical of the academic community. The academic world has always had a transnational range of action, with knowledge being transmitted from one scholar to another, then disseminated, without economic compensation being invariably necessary.

3. The quantitative significance of the globalisation of technology and the position of Europe

Once we have asserted that under the umbrella of globalisation of technology there are different phenomena, it will be important to check what is the quantitative importance of each of its main components. This will also allow us to assess how Europe is participating in the overall process, what is the impact of each of these forms and which are the policy implications. This is particularly important to design, at the local, national or European levels, appropriate policies.

It should however be reminded that in the majority of cases the available indicators do not report full information on the cateogries of globalisation here singled out. In some cases the indicators include heterogeneous dimensions, in other cases they do not report all the dimension. Nevertheless, the evidence here discussed is able to inform on the main significance and trends of the globalisation of technololgy.

3.1. International exploitation of technology

For a quantitative assessment, it might be useful, within this category, to separate between the embodied and disembodied components since both play a crucial role in firms' strategies (Evangelista, 1999). The former is captured by traditional international trade indicators, the latter by indicators of the transmission of knowhow such as patents, trade of licences, technical assistance and so on.

Table 2 recapitulates the evidence on this form of globalisation. Although all commodities include a technological component, there are some which are more technology-intensive than others. From the available classifications, it emerges that high-tech industries absorbe more than one fifth of the world trade in manufacturing (Guerrieri, 1997). This share has considerably grown and it has more than doubled in the last twenty five years. The position of Europe in this respect is hardly satisfactory. Its market share in the high-tech products has declined from 48.6% in 1970 to the 33.8% in 1995.

An indicator of disembodied knowledge is represented by patent statistics and, in particular, by international patent flows. Patents can be extended in foreign markets both to sell a product that embodies the innovation and to sell the innovation disembodied. Each patented invention is, on average, extended in three countries. A dramatic growth rate has occurred over the 1985-95 decade, equal to 13.3 per cent a year. This growth rate has been substantially higher than in industrial R&D expenditure, indicating that the trend in external patent applications cannot be related to an increased investment in technology but to a growth in the attempt to exploit the results of innovation in overseas markets. The markets where pay-offs for technological investement are seeked are becoming more and more global.

3.2. Global generation of innovations by MNEs

The evidence collected on the activities carried out by MNEs in host countries is more systematic, thanks to research carried out on the ground of indicators based on R&D expenditure and patents. The available evidence is presented in Table 3.
In terms of inward flows of R&D by MNEs, there are large variations over countries, from the 1 per cent of Japan (which is the most typical case of a system of innovation where domestic firms concentrate their investment in their home country and where foreign firms have serious access problems) to Australia, where

foreign firms account for nearly half of the total R&D of the manufacturing industry.

In the three main European countries, Germany, France and the United Kingdom, foreign firms account for, respectively, 16.5, 14.9 and 18.5 per cent of the total national R&D expenditure of the manufacturing industry (while the bulk is still national). A greater importance is played by foreign affiliates in Spain (see Molero, 1995), where they account for nearly one third of total R&D intensity of the manufacturing industries. Overall, Europe does not emerge significantly different in this respect from the United States, while it emerges that the penetration of foreign firms in Japan is still negligible (1.4 per cent of the national R&D of the manufacturing industries only).

Is there any R&D-based reason why a nation should prefer foreign firms to domestic one? Are host MNEs generally keener than domestic entreprises to invest in R&D? One way to check this is to compare the R&D intensity of national and foreign affiliated firms. In the United States, home and host firms have the same R&D intensity. In all other countries, with the exeption of Australia, the ratio of R&D expenditure to sales of foreign affiliated firms is lower than for national firms (OECD, 1997b).

In all the European countries, the R&D intensity of national firms (strongly dominated by the so-called national champions) is substantially higher than those of host firms. In Germany foreign affiliated firms report a ratio which is almost half than for national firms (it is however significant that in Germany also foreign affiliates have a very high R&D intensity), and in all other countries it is always lower. In other words, there is robust evidence that domestic firms are more R&D intensive than foreign ones.

This does not necessarily imply that R&D localisation by foreign companies should be at the detriment of the R&D investment of national companies. Although foreign firms might be less keen to invest in R&D in the country, there is no evidence that they crowd out the investment of natonal firms. On the contrary, there is abundant evidence that R&D centres tend to agglomerate. High R&D activity by national firms might therefore induce the localisation of foreign firms and viceversa (Cantwell, 1995). And, in fact, the R&D intensity of foreign firms is higher in those countries where the R&D intensity of national firms is also high.

Some evidence on the share of innovative activities carried out in host countries based on US patent statistics has been made available by Patel and Vega (1999). This shows that, by far, European firms as a whole have a much larger share of patents granted from foreign subsidiaries than United States and Japan (22.7 per cent versus, respectively, 8.0 per cent and 2.6 per cent of the total patenting of a sample of large firms). European large firms are much more international in the scope of their innovative activities than their American and Japanese competitors.

It is equally interesting to identify the geographical origin of this R&D investment and, in as much as Europe is concerned, the part which comes from other European firms and from firms ouside Europe. European firms distribute their activities between the United States and other European countries. Firms based in all European countries, with the exception of small countries such as Belgium, Finland, Austria and Norway, have a greater level of technological activities in the United States than in other European countries. The preference for localisation in the United States rather than in Europe is particularly significant for German firms (14.1% versus 6.5% of the total patents of German-based large firms) and British firms (38.1% versus 12.0% of the total patents of British-based large firms).

3.3. Global technological collaborations

Some evidence on the available statistics on global technological collaboration in both the business and the public sectors is reported in Table 4.

Concerning the business sector, we rely on the classic database developed at Merit by John Hagedoorn and his colleagues (see Hagedoorn, 1996). This has shown that as much as 60 per cent of the total strategic technology alliances recorded are international in scope. This form of generating technological knowledge has considerably increased its significance and the number of recorded agreements has doubled in a decade.

The largest number of alliances involve the United States: 45 per cent of all the strategic technological alliances recorded occur among American firms only. Moreover, the US has strong ties on both the Atlantic and the Pacific shores. On the contrary, the intra-European strategic technological alliances appear to be rather low: the recorded intra-European alliances in 1989-96 are only 10.8 per cent of the total, while those involving European and American firms are 26.3% per cent. This is particularly significant if compared to the period 1981-88, when the number of intra-European agreements was almost equal to European-US agreements (see Table 5). In other worlds, it seems that policies carried out at the European level to foster co-operation in R&D and innovation in the continent have not been able to reverse the propensity of European firms for American partners.

Partnership and collaborations promoted by public research institutions and universities equally play a crucial role in the international dissemination of knowledge (see Table 6). Indicators based on the number of undergraduate and postgraduate students and of the internationally co-authored scientific papers also show a substantial increase in the last decade. In a decade only (from 1985 to 1995), the percentage of internationally co-authored papers has incresed from 9.2% to 17.5% in the United States, from 14.0% to 26.2% in the UK, from 7.1% to 14.4% in Japan (see European Commission, 1997). A dramatic increase in the internationally co-authored papers - surely been facilitated by the diffusion of internet and of e-mail - is evident in all countries.

It is also significant to note that the European academic community is, in proportion, keener towards international co-operation that its North American counterarts. This is also associated to the relatively smaller size of European countries comapred the USA. However, the academic community in Europe is an asset which can and should be exploited to increase the trans-border circulation of knowledge and know-how.

4. Policy Analysis

Before to move to specific policy instruments, it is important to identify what public policies, at the national or European levels, should pursue on each of the three dimensions of the globalisation of technology singled out above. First of all, there is a crucial dimension which is common to each of the three components and that can be formulated as follows:

It is in the interest of a given territory to promote the inter-exchange of embodied and disembodied knowledge when this offers new learning opportunities.

The basic assumption of this statement is that the key to achieve nations' long run economic growth and welfare is to increase learning. Although the benefits associated to each knowledge-intensive transaction will not be equally distributed among the participating nations, the relevant aim of public policies should be to involve national economic agents in knowledge exchanges. In other words, it is better a bad deal than no deal at all. In the globalising economy it is very easy for a firm, an academic circle or an entire industry to become marginalized by the main knowledge flows. Since the pace of change is so rapid, the competitive position of the economy can easily be jeopardized.

There is a basic distinction to be drawn between the cross-border transmission of knowledge which *does* or *does not* allow endogenous learning: in the long run, it is not in the interest of a community to acquire systematically knowledge from aborad if the conditions to replicate it autonomously are lacking. This does not necessarily mean that each country should become self-sufficient in the generation of knowledge. No country today, not even the United States, is able to produce all the knowledge it uses; all countries are more or less specialized in selected science and technology niches, but surely none of them is self-sufficeint (for a quantitative assessment, see Archibugi and Pianta, 1992). But it is in the interest of each country to develop some recognized strengths in technology-intensive sectors to compensate fields where the country is dependent on knowledge and technology generated abroad. The main advantages and disadvantages associated to each of the three suggested categories are reported in Table 7.

4.1. Policies to face the international exploitation of technology

The international exploitation of national technological capabilities has often produced strong conflicts among governments and firms. Concerning the inward flows of technology intenstive products, there is generally low learning in consumption goods, while there is a more significant learning in the import of capital goods and equipment.

It is obviously an advantage for a country to exploit its technological innovations in foreign markets since it leads to the expansion of the internal production and of the areas of influence. A large market share, moreover, allows to achieve economies of scale and scope and therefore to preserve and develop the expertise in fields of excellence. There is a long and controversial practice of export incentives and today the trade rivalry is gaining importance in technology intensive sectors at expenses of traditional sectors: agriculture and materials are losing importance vis-à-vis electronics and software (see Scherer, 1992; Tyson, 1992).

But international trade rivalry is not only shifting within industries, it is also changing its nature and an increasing concern of policy makers has been directed to disembodied knowledge. Intergovernmental negotiations and litigations are more and more related to intellectual property rights violations, copyright infringements and similar issues rather than to the physical transfer of commodities across borders. In this area, there is a strong need to redefine the rules of the game (see David, 1999; David and Foray, 1996).

Within Europe, government policies are somehow limited by the integration acts adopted. In fact, the single market should favour intra-European trade while it should make more difficult for individual countries to protect their own internal market from imports from other European countries. The available data show that, in as much as technology-intensive products are concerned, there is also a strong propensity to trade with United States and Japan. The European policies aimed to the making a European technological identity have, so far, not been successful. This fact, however, does not necessarily lead to the policy conclusion that a new European protectionism should be implemented. It seems more important to increase European production and expertise in the rising industries than to limit imports from other countries.

There is also a strong need to redefine the rules for the trade of diesmbodied knowledge. One important step would be to agree on a common patent law, but we should also be aware that crucial components of contermporary knowledge, including software, are outside the scope of patent protection. The legal framework for intellectual property rights protection in Europe should therefore substantially wider than what can be provided by patent legislation.

While large firms easily have their own international networks to both sell their know-how and to acquire the knowhow from other firms, small firms do need support for both commercialize their innovations and monitor the international technological developments which might be relevant for their business.

4.2. Policies for the global generation of innovations by MNEs

What should be the attitude of governments towards:

a) national firms locating their R&D and innovation centre abroad; and
b) home-based MNEs investing in R&D and innovation at home?

There are both advantages and disadvantages associated with each of the two aspects. On the one hand, it is certainly an advantage if MNEs' hosted in a country also invest in innovative projects and contribute to up-grade its technological competence. On the other hand, there is the danger that the activities of MNEs will crowd out national firms. However, the risk of crowding out national firms is much more associated with FDI in the country than with the *technological component* of FDI: a strong presence of, for example, foreign automobile companies can be an obstacle to the development of a national automobile industy, but once foreign companies are into the country, there are no contraindications to the placement within the company of technology-intensive activities. In other words, governments might have their own reasons to encourage or discourage FDI, but once FDI is hosted there is certainly an advantage to adopt policies to foster a strong technological component.

But a substantial amount of R&D carried out by MNEs increases the dependancy of the nation on the strategic choices of foreign firms, which may have preferential ties with the governments of their home country. Once R&D investment by host MNEs is accepted, there is a wide range of public policies which should be carried out in order to secure the benefits to the nation and the loyalty of foreign firms.

It is equally controversial the assessment of R&D investment in host markets by the so-called 'national champions'. On the one hand, this can be seen as a lost technological opportunity for the home country, but on the other hand, it might be an open window into technologically dynamic countries which strengthen the competitive position of national firms.

From the public policy perspective, the reasons which induce firms to locate overseas part of their R&D and innovative activites should be explored.

Sometimes this can be related to the lack of the adequate infrastructures or human resources in the home country (and this will have direct policy implications). If, on the opposite, national firms consider significant to keep a window open on the technological opportunities of other countries, it is important that public policies help the dissemination of know-how acquired abroad in their nation.

As stated above, MNEs firms only can generate innovations globally. Small and medium sized firms are not generally using this channel since they have not the organization and the financial resources to invest in overseas R&D labs. But this does not mean that small and medium sized firms have not the need to acquire technical information from other countries. They might sometimes manage to bridge the gap by using other forms and most notably cross-border collaborations.

4.3. Policies for global technological collaborations

In the case of global technological collaborations, the distinction between inward and outward flows disappears since each country involved in a collaboration receives and provides some expertise simultaneously. Of the three forms of the globalisation of technology here discussed, this is the most typical example of a positive sum game since the members involved can manage to increase their expertise and the externalities associated with it. It is therefore comprehensible that an inter-governmental organization such as the European Union has stronlgy focussed its policy action on this category. This, in fact, does not provoke direct conflits among the participating countries since all of them can potentially take advantage from the collaborations promoted.

However, this does not mean that the advantages and disadvantages are equally distributed among the participants. As in many marriages of convenience, one of the partners can easily take advantage. In particular, it is likely that the learning potential of each partner will be different. The partner with greater knowledge will have more to teach but it will also be quicker in learning from others. Public authorities are not in the position to detect the learning potential involved in each collaboration. It is much more important for a country to become a junction of exchange of knowledge and technical expertise than to secure returns from each exchange.

The evidence available has shown, as expected, that the countries with the higher share of scientific and technical collaborations are those with the higher technological potential. This is hardly surprising since prospective collaborators are seeked among those who have already an accumulated knowledge.

Probabily, the most significant policy to foster cross-border collaborations has been implemented by the European Commission. In fact, the bulk of the financal resources of the European Union for science and technology have been devoted to schemes of collaborative nature. This has however been combined with the competitive selection of projects. The European Union has tried to select on the ground of competitive bids the best projects among those applicants willing to collaborate with teams in other countries. There is a strong economic rationale for applying such a combination of competitive and co-operative incentives. First, the competitive nature of the selection process should allow to fund the most promising projects. Second, the requirement of cross-border collaboration helps to disseminate and diffuse knowledge across regions with a view to achieve higher cohesion.

However, it has been shown that the European Union's schemes have not substantially altered the propensity of European firms towards American partnerships: on the contrary, the share of strategic technology parnership of European firms in the United States has increased in the 1990s. Even in the case of the academic community, which is much more dependent on public funding than business R&D, the European-American joint-ventures are on a par with the European-European joint-ventures.

This should raise serious policy concern. Are R&D funds managed at the European level too low in comparison to the R&D funds managed at the national level? Shall the general philosophy of promoting intra-European collaborations be revisited? Apparently, the European academic community is keener than the business community to international collaboration. This will suggest that policies which will increase public/business co-operation in Europe might also lead to increase international co-operation among firms. There is a significant opportunity to use the European academic community as a vehicle to a greater access to global knowledge networks.

It has often been discussed if the financial schemes to foster collaborations and partnerships of the European Union should be limited to member countries or should also be open to prospective collaborators from other regions, and most notably the United States. The view here suggested argues that the key discriminating point should be associated to learning: it might be in the interest of Europe to involve and fund the partecipation of selected non-European partners if this provides additional learning potential.

5. Conclusion

The suggested taxonomy of the globalisation of technology can help to understand the European gap in the learning economy and to inform policy actions. Although the evidence here reviewed is fragmentary, a few clear signals do emerge.

First, Europe is not at the core of the globalising learning economy. Europe is less integrated into the world markets than the United States in key dimensions of knowledge production, transmission and dissemination. Although the economic integration in the old continent has also involved new technologies, it does not emerge a clear-cut European system of innovation.

Second, the analysis of the three suggested categories of our taxonomy of the globalisation of technology provide some indications on where to focus on policy making, especially when this is carried out at a level, such as the European one, which is supra-national. In spite of the good mixture of competitive-co-operative incentives, the EC policies have not managed to change the balance of the European business and acadmic communities towards a substantial preference for partners in the regions. This is another indicator of the fact that a substantial part of the S&T expertise is not available in Europe.

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Table 1 - A Taxonomy of the Globalisation of Innovation

Categories	Actors	Forms
International Exploitation of Nationally Produced Innovations	Profit-seeking firms and individuals	Exports of innovative goods. Cession of licences and patents. Foreign production of innovative goods internally designed and developed.
Global Generation of Innovations	Multinational Firms	R&D and innovative activities both in the home and the host countries. Acquisitions of existing R&D laboratories or green-field R&D investment in host countries.
Global Techno-Scientific Collaborations	Universities and Public Research Centres	Joint scientific projects. Scientific exchanges, sabbatical years. International flows of students.
	National and Multinational Firms	Joint-ventures for specific innovative projects. Productive agreements with exchange of technical information and/or equipment.

Source: elaboration on Archibugi and Michie, 1995.

Table 2 - Empirical Evidence on the International Exploitation of Nationally Produced Innovatio

Indicator	Source	Results: Stock	Results: Trends
International trade	Guerrieri-Milana, 1995 OECD, 1996a Guerrieri, 1997	High-tech absorbes 21.5% of world trade in manufacturing	Growth of high-tech products from 9.5% in 1970 to 21.5% in 1995
Patents extented in foreign countries	Elaborations on OECD, MSTI, 1996c	On average 3 extensions for each patent Patents in fast growing and high-tech sectors are more likely to be extended abroad	Annual average growth of 13% in the period 1985-95
Technological balanc of payments	OECD, MSTI, 1996c	For the G6 countries in 1994 Payments were 11% of Business R&D Receipts were 16.4% of Business R&D	For the G6 countries in the period 1981-94 the average growth rates were 71% and 41.7% for Payments and Receipts respectively

Source: Archibugi and Iammarino, 1999.

Table 3 - Empirical Evidence on the Generation of Innovations by MNEs

Indicator	Source	Results	
		Stock	Trends
Inward flows of R&D by MNEs	OECD, 1997	Foreign affiliates account for from 1% (Japan) to 46% (Australia) of R&D in manufacturing	Significant increase in Europe Increase in USA Moderate increase in Japan
Outward flows of R&D in host countries by MNEs	USA Survey on R&D, National Science Foundation, 1996	7-10% of R&D of US firms is executed abroad (1980-93)	Small variations over time
Patents generated in foreign subsidiaries of large firms	Patents granted in the USA by a sample of large firms, Patel 1995; Patel and Vega, 1997	12.6% of patents is generated by foreign subsidiaries of large firms (1992-96)	Small but constant increase
	Patents granted in the USA by a sample of 284 MNCs, Cantwell, 1995	15% of patents of US and European MNEs is generated in foreign subsidiaries (1969-90)	Increase from 4% of 1920-24 to 19% of 1987-90
Ownership of high-tech establishments operating in the USA	National Science Foundation, 1996	In 1995 10.9 of high-tech establishments owned by non-US companies	n.a.

Source: Archibugi and Iammarino, 1999.

Table 4 - Empirical Evidence on Global Techno-Scientific Collaborations

Indicator	Source	Results	
		Stock	Flows
International inter-firm technical agreements	Hagedoorn, 1996 National Science Foundation, 1998	of inter-firm technical agreements are international.	Doubled over the1980s Slowdown in the 1990s
Number of foreign students enrolled in higher education in developed countries	Unesco, 1995	Share of foreign students from 1% to 17% according to country	Increase in absolute terms constant as a share of the total students
Number of foreign post-graduate students in the USA	National Science Foundation, 1996	24% students enrolled in post-graduate courses are foreign (1994)	Increase of 4% in a decade
Internationally co-authored scientific papers	European Commission, 1997	From 18% to 48% of co-authored paper have partners in more than one country	the number has nearly dou

Source: Archibugi and Iammarino, 1999.

Table 5 - Distribution of strategic alliances between and within economic blocs, by technology: 1980-96

	Number of Intraregional Alliency		
	Europe-Japan	Europe-US	Japan-US
1981-88	145	534	362
1989-96	145	845	361

	Number of Intraregional Alliency		
	Europe	Japan	US
1981-88	487	209	722
1989-96	349	79	1440

Includes all agreements reported for biotechnology, information technologies, and new materials.
Source: J. Hagedoorn, Maastricht Economic Research Institute on Innovation and Technology, Cooperative Agreements and Technology Indicators database, unpublished tabulations.
National Science Foundation (1998)

Table 6 - Percentage of internationally co-authored papers published i
selected industrialised and developing countries in all papers

Country	1985	1995
large advanced		
United States	9.2	17.5
United Kingdom	14	26.2
France	20	33.3
Germany	18.4	32.2
Japan	7.1	14.4
Italy	20	33
small advanced		
Netherlands	19.5	34.5
Sweden	21.7	38.1
Switzerland	31.8	47.3
Israel	23.7	35.9
Korea	27.6	27.9
large non-advanced		
Argentina	12.2	30.8
India	8.3	14.7
Mexico	30.2	43.1
Spain	13.5	29
USSR/Russian Federation	3.2	24.1
small non-advanced		
Greece	24.8	37.4
Portugal	41.4	47.8
Philippines	43	70.4
Malaysia	30	41.2
Chile	24.5	43.2

Source: RASCI, Data: Science Citation Index
European Commission (1997)

Table 7 - Impact of the Globalisation of Innovation on National Economies

Categories	Impact: Inwards flows	Impact: Outwards flows
International Exploitation of Nationally Produced Innovations	Low profile of national institutions. Low learning in consumption goods. Medium learning in capital goods and equipment.	Expansion of the market and of the areas of influence. Maintenance of national technological advantages.
Global Generation of Innovations by MNEs	Acquisition of technological and managerial capabilities. Increased dependence on the strategic choices of foreign firms.	Missed technological opportunities for the internal market. Strengthening of the competitive position of national firms.
Global Techno-Scientific Collaborations	Increase of techno-scientific flows and of sources of innovation. For developed countries, diffusion of their knowledge. For developing countries, acquisition of knowledge and learning opportunities.	

Source: Elaboration on Archibugi and Iammarino, 1999.