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Science, technology and innovation in European Politics

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Abstract

Throughout the history of the political economy of innovation, the patterns of territory, competition/co-operation, knowledge production/distribution, and public action have been constantly re-organised. The trends in Europe, since the post-war period, are a good example of this. The political and economic space created by the EU and pan-European integration process has been modifying the context for innovation throughout these decades. The current paper examines these historical transformations, and provides a critical picture of the context in which innovative European firms operate today. In so doing, the study acknowledges that changes in the 'real world' of politics and economics are accompanied by changes in the 'cognitive framework', both in terms of how innovation is understood and how public action is designed accordingly. Consequently, it is the main claim of this paper that the political economy of innovation is as much the result of the constraints and dynamics imposed by the globalisation/acceleration of the innovation process, as it is the result of an active socio-political construction through the re-alignment of public actions following a new interpretative and institutionally negotiated framework. The conclusions identify open research lines.

Keywords: Technology, European Union, European co-operation, Innovation Policy

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1. Introduction

The political economy of capitalism in Europe has undergone important transformations during the 20th Century. From the turbulent first half of the century, were the predominant liberal model saw the emergence of totalitarian regimes, to the 'golden age' of the post-war period with the development of the welfare state in the West and the emergence of a bipolar world order; and finally to the 'globalisation age' since the end of the 1970s with a relativisation of scales of the economy and politics, and a multipolar world order. In all these transformations, science and technology have had a central role, both as the subject and as the object of change. The relationship between science/technology and the state has received much scholarly attention following two broad lines of inquiry. Historians, sociologists and political scientists have examined the way in which science is related to state-building and political power (Williams and Edge 1996; Pestre 1997). On the other hand, economists have examined how the state creates the context for the innovation process through a set of public actions, as education, macro-economic policy, the regulation of economic transactions and appropriation of knowledge, direct funding of RTD activities, and the establishment of 'bridging' institutions for diffusion/exploitation of knowledge (Nelson 1993).

The current paper wants to bring these discussions up to the European level of analysis, basically because science and technology have also had a central role in the European construction. Since the post-war period, the process of European integration has created a new political and economic space beyond the borders of the nation-state1. The trans-national, inter-national and supra-national dimensions of integration have substantially changed the parameters of policy-making and of socio-economic dynamics in the Old Continent. And in these dynamics the Europeanisation of science and technology has been a central element. More precisely, though, this paper discusses how the political economy of innovation in Europe has developed since the post-war period. Focusing on the political and economic aspects (rather than social ones), the paper looks at issues like: the changing patterns of European technological collaboration, the relation between national and supra-national technology policies, and the explicit creation of a trans-national system with direct and 'systemic' incentives to the innovation process.

Obviously, the evolution of the political economy of innovation mirrors the developments of the overall European political economy. In the 'golden age' of the welfare state, all public actions towards science and technology were undertaken at national rather than supra/inter-national level (with the exceptions of CERN and Euratom). Yet the 1960s experienced a booming of pan-European technological collaborations of inter-national nature like ESA, ESO, EMBO/EMBL, Airbus, etc. European collaboration became interesting at a time when the costs of big science were too high: states pooled resources with specific expectations about larger appropriations. Indeed, there was another turning point at the end of the 1970s. The impact of the oil crises moved the political debate from 'pool-resources-to-reduce-costs' rationale towards a wider and truly preoccupation about the European technological gap. Competitiveness was no longer a national issue: it also became also a European one. The project of the Single European Market can also be interpreted against this backdrop. As should be the creation in the mid-1980s of

1 . By European integration I refer here not only to the European Union, but also to the entire pan-European economic and political architecture from the 1950s.

the EU's RTD policy. In its more than 15 years of quest for competitiveness, the European Union has positioned itself at the centre of the technological collaboration arrangements in Europe, actively participating in old and new pan-European organisations like ESF, Eureka, etc. Furthermore, the current turn in focus from RTD to innovation policy re-aligns previous policy areas like education, competition, market regulation, industry, etc. into a wide strategy which should enhance the innovative and adaptive abilities of the European system(s) of innovation.

The purpose of the current paper is twofold. Firstly, it is my intention to put these transformations into a ***historical*** perspective, stressing the political dynamics of this process in relation to overall European integration. The growing role of inter- and supra-national public action in Europe in the areas of science, technology and innovation since the late 1950s, has decisively contributed to the construction of Europe. Secondly, this paper wants to provide a picture of the ***current*** wider political and economic context where innovative activities take place. This has an interpretative intention, as it will place the firm's 'external context' within political parameters.

In discussing how the political economy of innovation has evolved since the post-war period, and how is it organised today, the paper takes two analytical-methodological points of departure. Firstly, it acknowledges that there are 'general' and 'European' trends, and that they are discernible. That both are deeply interrelated, and that the border between them is politically as well as cognitively constructed. Rather than searching for causal of relationships, I will treat the global/international and European phenomena as two different geographical levels of transformations. Secondly, this paper also acknowledges that the changes in the 'real world' of politics and economics are accompanied by changes of the 'cognitive framework'. The current paper departs from the double recognition of the important changes at both, the 'real world' of industrial organisation/innovation process, and at the cognitive frameworks of social sciences about innovation. In this sense, neither of the transformations can be reduced to the other. Consequently, this paper claims that the political economy of innovation is as much the result of the constraints and dynamics imposed by the globalisation/acceleration of innovation processes on individual firms/innovators, as it is the result of an active socio-political construction through the re-alignment of public actions along a new interpretative and institutionally negotiated framework.

The paper will proceed as follows. Sections two and three will analyse the arrangements during the 1950s and the 1960s-1970s respectively. Section four will provide an analysis of the rapidly evolving social, political and economic context as it was by the end of the 1970s beginning of the 1980s in Europe. This will serve as an introduction to the fifth section, which will discuss the technology initiatives in Europe during the 1980s. The innovation turn of the 1990s will be in the spotlight in the section after that, introducing a critical examination of the current context for innovation in Europe, that will be examined in section seven. The conclusion will provide a summary and briefly consider the research agenda concerning this topic.

2. The post-war settlements

In the aftermath of the Second World War, science not only had lost its innocence[2], it had also become a central concern of state politics. Irrespective of how national innovation systems are organised in industrialised countries today, the war represented a major turning point in all of them. The forms and economic resources of the state involvement in science and technology during and after the war varied considerably from state to state. However, in the post-war period it was evident that governments had understood the relevance of technology for defence and military issues as for generating economic growth. In terms of the particular ways in which state interventions were designed, the military and civilian aspects were weighed against each other, and the amount of economic resources allocated to the system, were different in the USA and in Western and Eastern European states.

The two super-powers emerging in the eve of the Cold War provided greater support for military and defence technology (Mowery and Rosenberg 1993). In Western Europe things were slightly different. Generally speaking, for countries like Italy, France, the UK, Germany and Sweden the post-war period represented the expansion of state public intervention in the main efforts to reconstruct the economy and the research system[3]. Naturally, reconstruction took different trajectories depending on the pre-war conditions of their respective national research structures. However, all European states shared a preoccupation with their own technological capabilities in relation to three questions, namely, the USA's and USSR's emerging technological hegemony (most significantly in the nuclear field), the 'brain-drain' of European scientists during and after the war, and the lack of appropriate laboratory and experimental facilities/equipment.

On the basis of this triple concern, European governments took an active part in the development of their national systems of innovation during the 1950s, 1960s and early 1970s. This followed essentially two lines: the overall framework of state-economy-society relations provided by the Welfare state legitimised strong state involvement; and the understanding that technological progress can be guaranteed by an adequate level of scientific knowledge lead to the formulation of explicit science policy. The first of these lines explains the massive public allocations; the second explains why governmental interests were primarily focused on the production of scientific knowledge, in the assumption that the exploitation of this knowledge in terms of industrial applications was somehow automatic and also beyond the reach of policy-making.

In the 'golden age' of the welfare capitalism of the 1950s, national states started building important institutions that were to be central for their national systems of innovation. Not only were the efforts to (re)construct public and private research organisations, but also a wide set of other actions were envisaged like the re-

2 Following the famous dictum of Oppenheimer, the nuclear physician who developed the first nuclear bomb in world history.

3 Naturally, the security dimension was also present in these efforts, however not quite so dominating as in the USA and USSR.

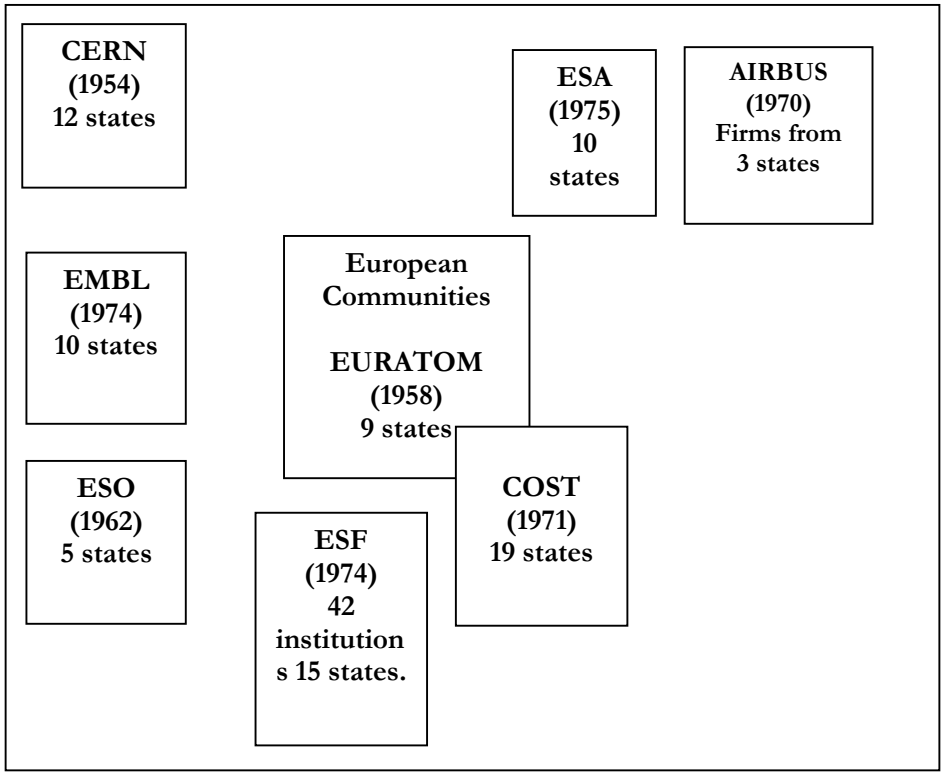
organisation and tremendous expansion of education structures, the socio-political construction of professions, the establishment of a regulatory framework for standards, and the support of strategic industrial firms either through nationalisation or by direct public creation. All these public interventions were obviously taken at national level, in the economic context of Fordist forms of production and Keynesian macro-economic policies. The majority of national systems of innovation were being created along with the construction of a new way of understanding the relationship between society, economy and politics: the welfare state. It is therefore not surprising that under the thrust of these trends the European level of public action was only residual, as it was limited to a single scientific domain: nuclear energy.

Historians of European politics have, for a long time, pointed to the central role that nuclear energy issues had in **the post-war settlements** (Guzzetti 1995; Krige and Guzzetti 1997). Research on nuclear energy earmarked the scientific efforts of the 1950s because there was a generalised belief among politicians that this source of energy was the starting point of a new industrial revolution (Guzzetti, 1995). Two inter- and supra-national organisations were created in this area, namely CERN and Euratom, which have operated independently from one another ever since (on basic and industrial research respectively). CERN's success story has had a tremendous influence in European collaborative schemes to be developed in the decades after. Created in 1954 due to the persuasiveness of some prominent nuclear scientists, the European Laboratory for Particle Physics has today a world-class system of particle accelerators (an impressive and costly installation near Geneve) and has been awarded several times with Nobel prizes. On the contrary, Euratom, one of the three European Communities, was created in 1958 and has focused mostly on applied and industrial research. Engaged in the design of nuclear reactors in its research facility (the Joint Research Centre, JRC), Euratom suffered from high-political conflicts in the 1960s due to the divergent national industrial politics in this matter. The launch of JET (Joint European Torus) in 1979 - a large programme concerning fusion, a potential alternative energy source - brought Euratom much of its lost shine.

3. The first bricks of the European scientific architecture

In contrast with the residuality of the European initiatives of the 1950s, the 1960s and 1970s saw a real wave of co-operative agreements in a panoply of different scientific fields, like molecular biology, space research and aviation. Based mostly on 'big science' and large investments, these initiatives earmark the starting point of a European scientific and technological architecture, based on the pooling of national economic and knowledge resources. Table 1 is a visual representation of the organisations being created in this time span, their member states, year of creation and relationships between each other.

Figure 1: The European Technological Architecture by the end of the 1970s.



In general terms, the collaborative patterns emerging in these two decades were characterised by four features: firstly, their scientific (rather than more technologically oriented) nature; secondly, the direct involvement of public (rather than private) financing; thirdly, their non-military nature; and last but not least, the creation of large installations and laboratories. In other words, European co-operation arrangements were based on big science, and in inter- rather than supra-national political structures. This means that they tended to follow the CERN, rather than the Euratom model.

EMBO/EMBL, ESA and ESO are three European organisations that most directly follow the pattern described above. To start with the first, the **European Molecular Biology Organisation** (EMBO) was created in 1970 due to the effective mobilisation of biologists for creating a sort of CERN for molecular biology. This organisation pushed for the creation in 1975 of a large laboratory (EMBL) in Heidelberg. The rationale behind its creation was, again, the belief that "molecular biology would be the science of the 21st century, as physics was in the 20th century" (Morange, 1997: 78), and the aim was to create a European response to the dynamic USA. The **European Space Agency** (ESA) has a similar rationale. Space research was, in the 1960s, a new field, which was dominated by the USA and USSR due to military rivalry. The European reaction to this came in the early 1960s with the establishment of two small organisations, ELDO (European Launcher Development Organisation) and ESRO (European Space Research Organisation). In 1975 both organisations merged into ESA, which today combines

activities in basic science and in industrial development[4]. A third European organisation for scientific collaboration is the **European Southern Observatory** (ESO), created in 1962 by five countries to operate an astronomical observatory in the Southern Hemisphere (in La Silla, Chile)[5].

Among the three organisations examined earlier, only ESA did not fit the four elements characterising the European scientific/technological collaboration in the 1960-70s, due to its purpose of bolstering up industrial development. However, we have another leading example of European collaboration in these terms: **Airbus Industrie**. This consortium of several European companies was established in 1970, and today consists of the new European giant EADS (80%)[6] and British Aerospace (20%). Airbus is the second largest producer of commercial aircraft carriers in the world after the US Boeing, and has around 25% of the market share[7]. Another European organisation that does not fit in with the parameters outlined earlier is **COST**. In contrast with the specific sectorial nature of all the previous arrangements, COST created in 1971, the first multi-sectorial form of scientific co-operation in Europe with a broad range of scientific and technical areas. This functional flexibility is mirrored in its organisational structure, which does not entail any large facility nor managerial staff. COST works as a sort of meeting point between national research institutions, universities and firms. Projects are financed and co-ordinated nationally. This model of collaboration influenced successive arrangements like Eureka, the EU RTD Framework Program, and the **European Science Foundation** (ESF). Established in 1974 under the auspices of the European Communities, today the ESF brings together 65 organisations within the research councils of 22 European countries, but is non-governmental in stricto senso.

Often, this spectacular development of technological/scientific collaboration in Europe has been explained on the basis of the economies of scale involved in big science. Certainly, the large costs of undertaking expensive scientific projects and installations have worked as a powerful argument for individual states to lump together their efforts. However, this 'economic rationale' cannot provide an overall, comprehensive, explanation in itself. Firstly, because science and technology are so essential in military-defence and economic terms, they naturally become a very sensitive area for public inter-national collaboration. The strategic element of science renders it a question of national interests. Secondly, results from technological collaborations are unclear and uncertain. Policy-makers can never be

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4 ESA differs from CERN and EMBL in two important points, namely, its flexible organisation and in its direct commercial application. Based explicitly in the 'fair return' principle, programs are divided into mandatory (carried out by all ESA members) and optional. Programs are developed through contracts awarded to industry in its member countries. Arianespace, created in 1979, is the best known among the companies developing ESA programs. ESA has large facilities in three European sites, and a launch base in the French Guyana.

5 A new facility is currently being built, the Very Large Telescope (VLT) in Paranal.

6 EADS (European Aeronautic, Defence and Space Co) is the new company resulting from the 1999 merger between the French Matras-Aerospatiale (of public-private nature) and DASA, the aeronautic division of the German Daimler-Chrysler (of private nature), which merged earlier with the Spanish CASA.

7 The success of their A310 and A320 aeroplanes in the 1980s was followed by the 330-200 and A340 in the 1990s. Plans for an expensive A3XX super-jumbo are currently on the agenda, willing to compete with the popular Boeing 747 which is 25 years-old.

guaranteed a certain type or amount of outputs from their 'investment' given the uncertainties always involved in any scientific-technological exercise. The lack of political control is a key issue for collaboration. One of the solutions to this has been the explicit 'fair return' principle operating in ESA, through which national firms get a proportional share of the contracts. But this is more the exception than the rule, especially because it is only ESA that has such an explicit out-sourcing system. Consequently, in a strict logical sense, these two key questions should have hindered European collaboration more than they allowed it. Yet, how could it be that European states engaged themselves in such a dense net of collaborative schemes? Why did they accept to give away part of their sovereignty in this particularly strategic issue?

To the 'costs of big science' explanation, John Krige has added a political one: the sum of national interests of individual European states that saw their economic-scientific capabilities severely diminished after the war vis-à-vis the USA (Krige, 898). Nevertheless, these two explanations constitute a necessary, yet not a sufficient, condition for the emergence of this particular form of European collaboration. From my point of view, the missing element is the cognitive framework concerning the relationship between science-economy-society-security, within which decision-makers operate. These have had a paramount importance in the development of not only the national systems of innovation, but also the technological aspects in the European construction. Following the recent theoretical attention given to the role of ideas in political economy (Wendt 1992; Blyth 1997; Cameron and Palan 1999) and in EU politics (Borrás 1999), the way in which the 'science policy frame' came to dominate among national policy-makers, shaped the contours of the European collaborative arrangements in the early initiatives from the 1950s to the end of the 1970s. The contours being namely the four features identified earlier: the bias towards basic rather than applied science, the public nature of the organisations, the decidedly civilian rather than military nature of research, and the creation of large installations.

If the first building blocks of the European scientific architecture were well established by the end of the 1970s, as shown in figure 1, the next two decades experienced a significant expansion and widening of European collaboration in these matters. Three new elements to be put in place are a new generation of scientific organisations like Eureka and the Framework Program, a truly European preoccupation regarding the technology (rather than the scientific) gap with its world competitors, and a focus on other aspects like human resources or industrial standards. The rapidly changing economic and social conditions by the second half of the 1970s were to trigger this new conception of European public action in science, technology and innovation. Next section addresses this changing context.

4. A new Europe in a changing world...

Since the end of the 1970s three major changes have altered the international and national political economy. These are the end of the Cold war, the globalisation trends, and the tremendous acceleration of the innovation process. These three changes have had important repercussions in the organisation of politics and

economics at world, European and national level, and they have represented a new context for the innovative activities (Peterson and Sharp 1998)[8].

Materialised symbolically by the fall of the Berlin wall in 1989, the end of the cold war has substantially re-shaped the structure of international relations and the understanding of security. Moving away from an interpretation national security in military-defence terms, most countries now emphasise 'economic security'(Lawton 1997). Most relevant for our interest in the innovation process and RTD policies is the fact that this political process has also meant the retrenchment of defence budgets, the emphasis now is being placed on dual-use technologies (Molas-Gallart and Robinson 1997).

Secondly, the globalisation of the world economy has signalled a major turnabout of contemporary economy. Indeed, its origins, its real extent, and its repercussions on the organisation at national level, are among the most hotly debated issues among scholars of political economy. By globalisation it is generally understood the growing internationalisation of the economy during the last two decades in relation to three dynamics, namely, the increased mobility of financial capital, the transnationalisation of production processes and increased trade flows, and the advance in transport and communication facilities. These phenomena have fostered an increase in the competitive pressures of markets, and have as well shown the limits of single national economic policies. Whereas there is still little agreement among social scientists about the nature and bonté of these trends, the social-constructivist school of IPE has pointed to the fact that globalisation has now become a discursive device providing specific cognitive parameters and being politically used as legitimisation for specific economic policies (Rosamond 1999). Either in its 'real' or in its 'cognitive-power' dimension, globalisation is transforming the context of social and political action, and is also transforming the context of innovative activities (Archibugi and Michie 1995).

The third phenomenon mentioned above is the acceleration of the innovation process. It is already a commonplace for industrial economists to point out the tremendous pace that technological development has reached during the last two decades. This acceleration has mostly been felt in high-tech sectors, where the life-cycle of their products has been reduced spectacularly. More than ever, the technological race, or the technological war, between firms and products is obvious to every single consumer in the developed world (Von Braun 1997).

Instead of discussing what the causal relationship between these macro phenomena is, I will just recall the organisational transformations that have accompanied them throughout these two decades. These are mainly new patterns of inter-firm competition-collaboration; new internal organisation of the firm (like decentralisation, out-sourcing, etc); new relationships between producers and consumers; and new patterns of knowledge production-distribution-appropriation. The significance of all these new organisational trends means that, beyond a mere acceleration of the technological development, the overall pattern of the innovation process seems to have changed as well, characterised by more complex interaction forms between the firm and the 'external context' and within the firms' walls.

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8 This paper follows close and elaborates further on the five changes of the international political economy of RTD policies identified by these two authors.

The rapid rate of European integration since the mid-1980s has been interpreted as the 'European response' to this globally changing context (Stone Sweet and Sandholtz 1998). Indeed, the question of 'why' and 'how' did these European trends take place lies at the very heart of the alternative explanatory interpretations of the diverse integration theories (Kelstrup 1998). Without introducing much of these otherwise large and interesting debates, my purpose is just to mention the major hints of such a European 'renaissance' as means of contextualising the salient developments of the European political economy of innovation in the 1980s and 1990s.

Starting with the European Union, the significant 'deepening' of this organisation during the last 15 years - with ambitious projects like the Single European Market and Economic and Monetary Union, and with new competence areas (like environment, unemployment, immigration, security, and internal-judicial affairs) enshrined in the successive treaty revisions - have raised questions about the federalising nature of the project. All in all, these large and specific moves have been constructing a new economic and political space beyond the nation-state. From the economic point of view the European Union now counts with major policy instruments of macro-economic, allocative and regulatory nature, sometimes shared with the member-states, sometimes in exclusive terms. Along with this expansion of competencies and political role, the Union has also experienced a geographical expansion with important repercussions, as the subsequent Southern, Nordic and future Eastern enlargements have gradually placed the European Union at the core of the political and economic order of the Old Continent. Beyond the EU, the pan-European scale of inter-national co-operation has also changed in important ways. Most notoriously, the enlargement towards East of pan-European organisations like OSCE, NATO, or the Council of Europe mirrors the trends of the new world order(Croft, Redmond et al. 1999).

The political economy of innovation in Europe has obviously transformed along these macro- and European trends. Not only has the establishment of a large market (with the dismantling of technical barriers to trade) and the integration of capital and financial structures shaped a new context for innovation. The new de- and re-regulatory trends at EU level, in sectors like telecommunication and electricity, and in policy areas like competition policy, or public procurement have as well had a major impact in this sense. However, this set of political events, although constituting a more or less homogeneous trend of the European economic integration process, were never explicitly designed to constitute a new context for innovation. Rather, they followed their own policy rationales and political dynamics along the common lines of creating a larger market. It was as late as the mid-1990s when policy-making at EU level re-considered all these policy areas together as providing a specific context for innovation.

5. …for technology

The creation of **Eureka** and the **European Union RTD Framework Program** earmarked the decade of the 1980s. Their multi-sectorial, multi-annual, together with their well endowed economic resources have placed them at the core of the current collaborative architecture. Both their creations, in 1985 and in 1984 respectively, resulted from the European anxiousness of a growing 'technology gap'

vis-à-vis its world competitors, the USA and Japan. More specifically, scholars have insisted on the leading role of France for the establishment of Eureka as a countervailing to similar RTD schemes in the US (the SDI initiative of Reagan). Alternatively, the establishment of a RTD policy in the EU has been explained in terms of the purposeful opportunism and pro-active role of the Commission, who allied itself with some few large firms (especially the so called Big 12) [9], convincing initially sceptical national politicians (Cram 1997) (Peterson 1991) (Peterson 1992), and inspired by the Japanese VLSI program (Sharp, 1991). These accounts, based too much on the protagonism of individual actors/organisations pursuing strategic alliances in support of their interests, do not consider the underlying cognitive dimension related to these new political initiatives.

This cognitive dimension consists of three processes. Firstly, the inner learning curve from previous successful and failed collaborative agreements in Europe. Sharp has long pointed at the three lessons learnt along the 1960s and 1970s, namely, flexibility, functional specificity and market-industry driven (Sharp 1991)[10]. As a matter of fact, the proposals for further collaborative arrangements did not come as a complete ex-novo pattern of public action: European states knew well what to expect from them, and also knew well how to organise them in a viable way. Secondly, the initiatives proposed suited the new premises about the public involvement of the time. In the 1980s, focus on the technological and industrial application of knowledge was on the front line of policy-making. The earlier emphasis on science policy, devoted to the expansion of the knowledge frontier, was perceived to be insufficient to foster the competitiveness of the economy. Public action should pro-actively help establishing the link between knowledge production and the final hi-tech product. Thirdly, and most importantly, the suggested programs fit generally well within the general atmosphere in Europe, especially the establishment of a single market enhancing the trans-national dimension of economic transactions as mean to exploit and allocate optimally the resources. The leading argument for the SEM, namely the 'costs of non-Europe' could easily be applied to the technological field through the 'European technology gap'. It is precisely the cognitive and symbolic dimension related to the 'European gap' that shows the magnitude of the turning point in European politics towards technology at the mid-1980s, in contrast to the science-based collaboration of earlier decades.

However, the constitution of the new and stronger collaborative schemes in the 1980s was not a smooth one. This was not only due to the question of *identity* related to the new 'Europeanisation' of the competitiveness problem, but also to the question about the extent and forms of public intervention in science and technology issues in a period of predominant liberal and right-wing *ideology*. Referring to the first, Bray has shown the important resistance of some national institutions to Europeanise technological collaboration along these lines (Bray 1996). Similarly, Sharp has pointed to the tension between the liberalist-interventionist ideologies in the eve of the Single European Market project, the former being opposed to the establishment of a Framework Program (Sharp 1991). These two sorts of political tensions in the trends of the European technological collaboration (the national-European and the ideological one) are the utterance that

9 This was formed by the largest IT European firms.

10 Among the failure cases not mentioned earlier are the Concord project, Unidata and Euratom as such in the 1960s.

the transition in the 1980s entailed a negotiation process among alternative visions. The co-existence of Eureka and the EU RTD Framework Program can then be seen as the expression and a compromise between these alternative conceptions: the former being market-driven and State controlled, whereas the later being supra-nationally controlled and more pre-competitive oriented. Hence, these tensions resulted in a clear division between the arrangements of supra-national and inter-governmental nature, and within each such scheme, between the member and the non-member states. The next section will show how these two characteristics have changed dramatically in the 1990s.

In addition to the Eureka and the Framework programs, the 1980s saw another set of public initiatives at the European level, directly affecting technology. Amongst the most important of them where the competition regulations within the EU, and the standardisation and European patent procedures at pan-European level. As we will examine here, these three regulatory fields have not been developed in a coherent nor articulated way. Rather, they have emerged in an ad-hoc manner, generally responding to specific problems.

Competition policy, the key regulatory and controlling mechanism of the single market, was partly modified in the mid-1980s in order to accept horizontal R&D agreements between firms. All sorts of collaborative agreements between firms potentially leading to market domination and unfair competition are generally prohibited. Therefore the block exemption to these technological collaborations, including joint ventures, meant an indirect legal incentive to European firms[11]. Moreover, in 1989 the EU acquired competencies in the field of merger control. These prerogatives have been used by the Commission to force merging firms to out-source, sell or divide their technological capabilities, preventing a potential dominant position in a technological field (Armstrong and Bulmer 1998).

European standardisation procedures introduced major reforms in the 1980s. Half way between EU and pan-European nature, the main standardisation bodies, CEN, CENELEC and ETSI, introduced a new and flexible approach to technical harmonisation. The reason for such re-organisation was related to the Single European Market: Standardisation was perceived as a key issue for overcoming the non-tariff barriers to intra-European trade, and for technology purposes, namely, rationalising production forms, controlling variety and enhancing technology transfer (Vad 1998).

Last but not least, the European Patent Office (EPO) is the most significant mechanism for a pan-European context for innovation, through the regulation of this specific form of intellectual property rights. Created in 1977, this self-financing organisation is formed today by 19 member states: the EU15 and other 4. Patent protection is granted in a demand-basis, that is, in as many EPO member and extension states as the applicant wants. In 1998, the EPO received 113,400 applications. This system has recently been criticised for being too expensive, and the EU is now considering launching a community patent. We will examine this in the next section in relation to the new emphasis on intellectual property rights at European level.

11 Directives 418/85 of 19 Dec. 1984 and its latter modification in directive 151/93, OJ 1993 L21, p 8.

Summing up, the 1980s were marked by an important expansion of collaborative schemes in relation to the political ambition of bridging the European technology gap with world competitors. However, these efforts were not followed by a consistent set of further policy instruments aiming at improving the conditions of innovative processes at European level. The initiatives taken at EU and pan-European level (like standardisation, patents and the legal acceptance of inter-firm technological collaboration) were important and interesting, yet quite limited in functional and operational sense. Direct political concerns for creating better contextual conditions for innovativeness at European level is a much newer phenomenon in relation to 'innovation' policy.

6. Widening the scope: The innovation policy paradigm of the 1990s

The 1990s have experienced a turn from technology to innovation policy. This move constitutes a new policy paradigm, the innovation paradigm, in so far as it is reconsidering the role of public action along with a new theoretical understanding of the economics of innovation. Besides the transformation in the 'real world' of industrial organisation mentioned in previous sections, the interpretative universe about the nature of innovation and technology, as an essential basis for policy formulation, has been changing too. The theories of evolutionary-institutional economics and of sociology of science have emphasised the essential social and institutional embeddedness of the innovation process. Thus, they provide an alternative understanding to the linear model of neo-classical economics which assumed an unproblematic transition from scientific knowledge and market innovativeness. The concept 'national systems of innovation' developed academically in the early 1990s (Lundvall 1992; Nelson 1993) has become a central analytical instrument within this new theoretical framework. This notion had the virtue of introducing an analytical approach to the 'external context' of the innovation process. Differences in the innovative performance of states could be explained on the basis of the different and historically developed sets of formal and informal institutional arrangements that form the context where the innovation process takes place.

The role of public policy in this new understanding has also transformed. On the one hand, the systemic and institutional perspective has opened up for a wider vista of the elements that are at play in the innovation process. Policy-makers are generally acknowledging that if the innovation process is so deeply embedded in social institutions, then the policy fields that have an impact on it are more than merely the RTD and standardisation procedures. They also involve education and human resources, the nature of the financial system, company and business law, procurement policies, labour market regulations, industrial policy, etc. Innovative performance lies at the crossroads of a much wider set of functional areas. Policy-makers no longer recognise the 'horizontal' nature of innovation, but its 'systemic' nature. On the other hand, parallel to the penetration of this new understanding within the respective national ministries and public sphere, theoretical economists have been actively involved in the normative formulation of specific policy rationales (Andersson 1998; Lipsey and Fraser 1998). In this sense, they have argued for public action that enhances diversity (Cohendet and Llerena 1997), that enhances learning processes (Dalum, Johnson et al. 1992), and that focuses on

other type of failures which go beyond the mere 'market failures' of previous policy rationales (Malerba 1996; Smith 1996).

This innovation turn has been visible at different levels of policy-making (Metcalfe and Georghiou 1998). At European level there are two large factors that might have played a central role for this turn, namely, the socio-economic context and the emergence of the new policy paradigm. The socio-economic context of the European Union at the beginning of the 1990s was characterised by the concerns about high unemployment rates, about slow growth indexes, and about the weakness of the competitive position of Europe in world markets. This was taking place in a political situation where the completion of the Single Market project and the commitment towards a single currency were a reality, and where the Commission needed new strategic lines after the charismatic presidency of Delors. The 1994 White Paper (Commission 1994) was a response to this double economic and political context. It is striking though, that technology matters have a rather central position in the paper. The notion that innovation was partly the solution indicated the penetration of a relatively new cognitive parameters that insisted on a wider and more 'systemic' vision of innovation vis-à-vis the previous lineal expectations of technology. Three issues have been mentioned in relation to the complex construction of this new cognitive context, namely, the role of the OECD, the evaluation exercises of the Framework Programs, and the strategic and policy analysis developed within the Commission (Sanz and Borrás 2000).

The green paper on innovation in 1995 (Commission 1995) confirmed this trend, elaborating on a systemic approach that identified the deficiencies of European, national and regional public action towards the attainment of a positive and incentive context for innovativeness[12]. The three lines of action elaborated on this basis[13] are: to foster a genuine innovative culture (training, education, exchanging best practices in industrial performance and public policies); to establish a framework conducive to innovation (European patents, to ease start-up firms, financial accessibility); and to better articulate research and innovation (flexible RTD programs, foresight, more international collaboration). Hence, the most salient advancement of the action plan is its re-consideration of a host of public actions towards the innovation objective, an intermediary towards competitiveness and job-creation. Most recently, the Commission has engaged in a similar strategic thinking towards the creation of a 'European research area', which contains and develops some of the ideas already exposed in the green paper[14]. Next section will examine the current European context for innovation shaped by policy means.

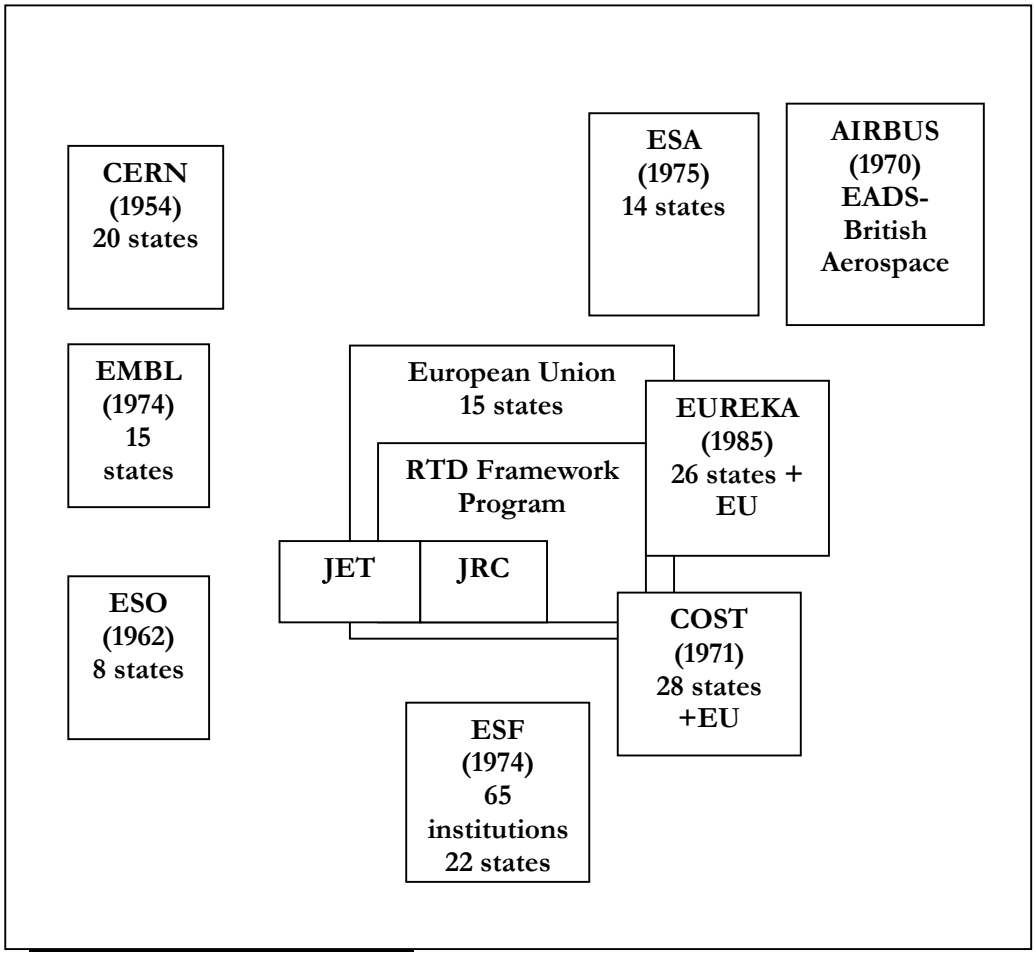
It is not adventurous to affirm that the green paper represents the Commission's political agenda of building a European system of innovation. Indeed, the question about to what extent the overall political economy of innovation in Europe is configuring a post-national innovative system is a hotly debated issue among scholars and policy-makers. Some argue it as an on-going process: "This emerging post-national system of innovation produces and is produced by specific post-national institutions that are both formal (treaties, community programs, and other European schemes) and informal (networks, common habits and norms)"

12 Green paper on innovation Com (95) 688
13 The first action plan for innovation Com (96) 589
14 European Commission (2000): "Towards a European Research Area" Com (2000) 6, 18 January 2000.

(Caracostas and Soete 1997): 397. To others, such approach obscures "the substantial diversity which persists within the EU in terms of scientific and innovative capacity", mainly among countries and among industrial sectors (Metcalfe and Georghiou 1998) :85.

Along with the 'innovation turn' of this EU policy, the overall picture of *the European scientific/technological architecture* has also been rapidly changing in the 1990s. The notorious geographical expansion of the pan-European collaborative schemes, and the increasingly interaction between them all is resulting into a new pattern of the European technological architecture where previous distinctions between Eatern-Western and between pan-European and EU are being significantly blurred. About the former, the end of the Cold war has opened the way for a further enlargement in most of these organisations with new Eastern European members. Examples of this include CERN, Eureka, and Cost 15.The Eastern enlargement means a significant blurring of the previously neat East-West division, and disentangles technological collaboration from military elements in a new European security order.

Figure 2: The European technological architecture since the 1980s until today



15 There are as well interesting exceptions to this enlargement, as EMBL, ESA and ESO do not have Eastern European countries among their newest members.

As can be seen in table 2, the clear distinction between the European Union and other pan-European (inter-nationally organised) technological schemes is also being currently blurred. This is due to several dynamics. In the first place, the frontiers of the EU Framework Program are no longer confined to the 15 as many non-EU countries are currently participating full-fledged into it through bilateral agreements (Island, Norway, Israel, etc). A second aspect pointing at this is the fact that the EU takes active part in the multi-sectorial Cost and Eureka[16]. Last but not least, the EU has lately enhanced its international collaborative linkages with the rest of pan-European arrangements (agreement with CERN and ESA).

7. Shaping the external context in Europe

Innovation policy is further a more 'firm-oriented' approach than the previous RTD and scientific ones (Dodgson and Bessant 1996). At national level, efforts during the 1990s have been focused on supporting networking, enhancing bridging institutions, fostering technology diffusion, and foresight studies. Whereas detailed empirical research about the extent of these national policy trends, and about the mechanisms of their institutionalisation is still needed, some studies have shown interesting convergence along the mentioned lines (OECD 1998)and EIMS project). In any case, it seems obvious that the wider understanding along the 'system's approach' has had its influence on the way in which national governments have been re-organising public action in this domain.

At European level, the 'innovation turn' of EU policy and the new patterns of the European scientific/technological architecture have contributed to the development of a richer and more complex context for innovative firms at inter/supra-national level. A quick survey can pin down four groups of elements conforming to this new context. Firstly, the fast developments concerning the regulatory framework in industry and technology-related areas, secondly the on-going transformations of the financial aspects of innovative undertakings, thirdly the strengthening of the social aspect related to knowledge production and dissemination; and finally, the novelties of the institutional-organisational context.

Starting with the *regulatory context*, the recent political attention to intellectual property rights (IPRs) at EU level reflects concerns about the legal protection of knowledge appropriability at supra-national level. In contrast with the extensive legal competencies in the field of competition policy, IPRs have been the 'Achilles' heel' of regulatory framework for innovative activities. The legal problem is based on the mismatch between the national jurisdiction in the exercise-regulation of such rights, and their abuse at trans-national level, which is against the principles of a single market (Govarere 1996; Anderman 1998). In this sense, the launch of the 'green paper on community patents' in 1997[17] is one of the most determined political actions from the Commission in this subject, following similar initiatives in

16 The EU and Cost are closely related to each other in administrative terms, on the other hand EU is a partner of Eureka and the greater efforts for co-ordination have recently been harnessed.
17 Com(97)314.

the field of trade marks[18] and other related rights[19]. Despite the well functioning of EPO, the EU has for long criticised the high costs involved in the issuing of patents and the uncertainty of the real legal protection (given the different legal systems where it operates), which could be both substantially diminished by a Community patent within the EU legal system. Procurement policy, a key issue in the Single European Market project, is becoming an issue in academic debates in relation to innovation. Some scholars criticise openly the 'conservativeness' of national practices, under-exploiting the technologically strategic dimension in public tenders. More decided action at European level could help reverse this situation (Edquist and Hommen 1998; Edquist, Hommen et al. 1998). Similarly, other voices are arguing for a European defence procurement policy (Hayward 1997; Vlachos 1998). Successful experiences of co-operative initiatives at pan-European level (i.e. the building of Eurofighter, a military airplane), the centrality of defence industry in high-tech and competitiveness-building, and the radical changes in the European security scenario, advocate for such political initiative.

The *financial context* for innovative activities has been also changing dramatically during the last few years, both in terms of public schemes for RTD and the availability of private venture capital for high-tech start-off firms. Since the mid-1990s, *public support for RTD* projects has been partly reconsidered along two main lines. Firstly, the financial constraints related to the convergence criteria of the EMU have meant important retrenchments in public support to RTD projects. Secondly, policy-makers have been more eager to examine the additionality question, or to the extent to which public support is not used to substitute expenditures which would be made anyway. In other words, a careful analysis of the boundaries between financial incentives and plain subsidies. This general attitude also applies to the EU Framework Program: although the allocations to the newest V Framework Program (1999-2002) have benefited from slight increments, the strengthening of the additionality criteria and dissemination plans of individual projects reflect this general trend.

A true *market of high-risk capital* for small high-tech firms has for long been absent in Europe. As a result, most of these firms quoted their shares in the USA's successful Nasdaq. However, recent private and public initiatives are reversing this situation. Since the mid-1990s a several national stock exchange markets have been created for such firms, the most salient of them being 'the Neuer Markt' in Frankfurt and the 'Nuveau Marche' in Paris. Recently however, the Paris, Frankfurt, Brussels and Amsterdam markets have formed a network, called Euro. NM , which has attracted a total of 95 listings since the beginning of 1997. Easdaq, a pan-European rival to Euro NM modelled on America's Nasdaq market, lists 27 stocks. These two markets are growing spectacularly, as Easdaq's index has risen by 168% and Euro. NM's by 322% since the beginning of 1997 (The Economist, 13-Jun-98). However, these markets are fragile, as many European start-up firms still find the US market more attractive, and as the trading volume of both is still quite small in absolute terms. The European Commission's Action Plan stressed that one way of stimulating these markets could be through tax incentives. The former French finance minister Strauss-Kahn followed such suggestion: A new type of life-

18 The creation of the new EU office of trade marks in Alicante (Spain).
19 Green paper on authors' rights and other related rights Com (95) 382.

insurance policy is tax-exempt if half is invested in shares, provided that at least 5% goes into small-company stocks.

A third element of the current European policy actions is the heed paid to the *social dimension* of the innovation process. Along with the premises of the 'knowledge-based economy' and 'learning economy', and with the concerns about job-generating economic policies, the issues of human capital, education, training, mobility and life-long learning have acquired a front-line position. The EU initiatives in the areas of training and mobility established in the 1980s, have been reinforced in the 1990s with successive Commission initiatives in the field, in the form of communications and white-green papers[20]. Similarly, concerns of polarising trends in relation to regional economies have fostered the introduction of technology-related chapters in the large programming exercises of the structural funds (Landabaso 1997). This implies a relative rapprochement of EU regional and RTD policies in a convergent objective: reducing the technology gap *within* the Union. Bioethics is another issue that, although having a clear regulatory nature, can best be included in this 'social aspect' of technology. Along with national and pan-European developments, the European Union is also taking major initiatives in this area. Most controversial of all has been the recent directive of biological patents, due to the ethical discussions on the limits of what might be patented[21].

Finally, EU initiatives have also been directed towards the reinforcement and Europeanisation of the *institutional context* for innovation. The fostering of bridging institutions, the provision of resources and other incentives for networking activities, the emphasis on diffusion-information mechanisms (through data-bases, networks of relay-offices, etc), are initiatives along this line. More discrete than other EU initiatives, incentives for informal and formal institution-building at European level might in the long run have a strong impact.

8. Concluding remarks and lines for further research

As Europe moves closer in political and economic terms, so does the context for innovation in Europe too. The slow pace economic integration from the 1950s to the 1970s meant that the scientific-technological efforts were mostly national. However, this did not prevent the construction of a European architecture in this area, formed by a set of scientific organisations-installations of inter- and supra-national nature. The Euroforia of the 1980s extended also into the technological field, as the identification-construction of a 'European' problem (the technology-competitiveness gap vis-à-vis USA and Japan) prompted the launch of new and ambitious co-operative schemes (Eureka and the EU RTD Framework Program) and a small set of complementary measures like standardisation. Political attention

20 The most relevant documents- action plans are: the White paper on "Teaching and Learning. Towards the learning society"COM(95) 590; Learning in the information society - Action plan for a European education initiative (1996-98), COM(96) 471; the Commission communication "Towards a Europe of knowledge" COM(97) 563, and the Green paper: "Living and working in the information society: People First" Com(96) 389.

21 Directive 98/44/EC, OJ L 213, 30/07/1998,p. 0013-0021

to these issues has been growing ever since. In the 1990s the problem of unemployment has been added to the (lack of) competitiveness, and innovation (rather than just technology) has been politically perceived as a plausible solution. A myriad of already existing and new political initiatives has been re-articulated under the innovation title, and the Commission has been quite pro-active through its 1995 Green Paper on Innovation.

The transition from these three stages in the history of the European political economy of innovation does not merely correspond to the given context in politics, nor to the emergence of specific political alliances supporting individual initiatives. They are fundamentally related to the historically changing attitudes and cognitive frameworks of what is understood by innovation and of how can/should governments do in order to enhance it.

Analysing the current political economy of innovation in Europe is both a daunting and an exiting academic exercise. As long as EU action has been significantly expanding from RTD to innovation, so the boundaries with the Maastricht-created industrial policy have become more blurred. Similarly, as national and regional governments are introducing also this systemic approach, the division of tasks between them all become also unclear. Yet, defining functional and geographical borderlines should not constitute a major concern but for bureaucrats. What is most important though is the question about how to manage the emergent complexity of such a diverse set of policy instruments into coherent and synergetic ways, tackling effectively the pitfalls and hurdles that innovative firms face today in Europe. Economists have been good to provide a new understanding framework and normative statements to policy-makers, however they have not provided clues as how to effectively manage such complex context-oriented new policy. This is perhaps a task for scholars in policy analysis and public administration. Such a scholar exercise requires an extensive functional and comparative analysis of the diverse policy-instruments and economic dynamics related to them, exploring in depth the shape of the new political economy of innovation. Specific areas for this opening research agenda might include:

- Defence, security and technology in Europe
- Cohesion, regional disparities and technology.
- Appropriation, diffusion and technological trajectories: intellectual property rights and standards.
- The social dimension: human capital, social capital, bioethics, information society, participation in science decision-making.
- The organisational dimension: improving adaptability within firms, improving adaptability and enhancing bridging institutions, SMEs technological ability, Multinational Companies' embeddedness in the local economy.
- Industrial and competition policies' relation to innovation policy.
- The internationalisation of European technology.
- Improving the patterns of technological collaboration in Europe.
- Financial markets and venture capital in Europe.

At a more academic level, further research must consider most explicitly theoretical discussions within studies of political economy about why the European political context for innovation has developed as it has. Susan Strange model of power

structure in international political economy included 'knowledge' as a key factor (Strange 1988). Recent efforts to develop this have brought about interesting scholarly discussions (Talalay, Farrands et al. 1997). Similar debates could be brought at European level, combining them with the intense and renewed theoretical debates in EU studies in the examination of how technology has been at the core of the European construction.

9. Acronyms

CERN: Conseil Européen pour la Recherche Nucléaire, known as well as the European Laboratory for Particle Physics.
JET: Joint European Torus
JRC: Joint Research Centre
RTD: Research and Technological Development
SDI: Strategic Defence Initiative
SEM: Single European Market
SME: Small and Medium-sized Enterprise
VLSI: Very Large Scale Integration program

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