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## Content

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<b>1. Executive summary</b> .....	6
Overall introduction .....	6
1.1. Conceptual analysis of social systems of innovation and production: what is a system of innovation? (Work Package A).....	7
1.2. Structure and stability of systems of innovation in 22 countries (Work Package B).....	8
1.2.1. OST research results and methodology on typology and dynamics of Social Systems of Innovation and Production (SSIP) : what perspectives for the European Research Area ? (Rémi Barré, Yann Cadiou, Françoise Laville, Sandrine Paillard, Sandra Petit).....	8
1.2.2. TIK results and scientific activities.....	13
1.3. Specific crossed perspectives on systems of innovations: the regional and multinational firm levels (Work Package C).....	15
1.3.1. Rotterdam School of Management (Erasmus University) research and results on multinationals and systems of innovation: towards an international interactive perspective (P. Beije, D. van den Berghe, P. Boekholt, A. Brechje, M. Lankhuizen, R. van Tülde, A. Wulff).....	15
1.3.2. OST results and methodology on S&T Co-activity in Regions : an Insight in the Geography of the Knowledge-based Activities in EU (M. Zitt, S. Ramanana-Rahary).....	20
1.4. Questioning the “internationalisation” of innovation systems (Work Package D).....	22
1.4.1. On the development paths of innovation systems (B. Amable, Y. Cadiou, P. Petit) .....	22
1.4.2. Looking at technology transfers and at the forms of internationalisation .....	23
1.4.3. Venture capital and innovation financing.....	23
1.4.4. Challenges on SSIs: towards a phase II.....	24
overall conclusions – innovation policies for the social systems of innovation and production in the context of the European Research Area dynamics .....	27
On innovation policies .....	27
On strategic policies looking at international co-operation and competition.....	28
<b>2. Background and objectives of the project (including reorientations)</b> .....	30
2.1. Objectives .....	30
2.1.1. Systems of innovation are important: the current state of the art .....	30
2.1.2. Causes and consequences of contemporary changes in national systems of innovation: the core issue of this project .....	32
2.2. Work content - Methodology .....	32
2.2.1. Conceptual analysis of social systems of innovation and production: what is a system of innovation? (Work Package A) .....	32
2.2.2. Structure and stability of systems of innovation in 22 countries (Work Package B).....	33
2.2.3. Specific crossed perspectives on systems of innovations: the regional and multinational firm levels (Work Package C) .....	34
2.2.4. The impact of economic integration and internationalisation (Work Package D).....	35

<b>3. Scientific description of the project results and methodology</b> .....	37
3.1. Conceptual analysis of social systems of innovation and production: what is a system of innovation? (Work Package A).....	37
3.1.1. CEPREMAP results and methodology (Bruno Amable, Pascal Petit).....	37
3.1.2. TIK results and activities .....	43
3.2. Structure and stability of systems of innovation in 22 countries (Work Package B).....	44
3.2.1. OST research results and methodology on typology and dynamics of Social Systems of Innovation and Production National: what perspectives for the European Research Area ?.....	44
3.2.2. TIK results and scientific activities.....	59
3.3. Specific crossed perspectives on systems of innovations: the regional and multinational firm levels (Work Package C).....	63
3.3.1. ROTTERDAM SCHOOL OF MANAGEMENT research and results on multinationals and systems of innovation: towards an international interactive perspective.....	63
3.3.2. OST results and methodology on S&T Co-activity in Region: an Insight in Geography of Knowledge-based Activities in EU .....	74
3.4. Questioning the “internationalisation” of innovation systems (Work Package D).....	83
3.4.1. Introduction.....	83
3.4.2. Expanding the data analysis to the sub systems of external relations and finance.....	85
3.4.3. Venture Capital and innovation financing.....	88
3.4.4. Challenges on SSIs: towards a phase II.....	90
<b>4. Conclusions and policy implications</b> .....	94
4.1. Conclusions .....	94
4.1.1. Introduction: the problematic of the present phase of internationalisation and it's effects on the complex architecture of the SSIPs .....	94
4.1.2. Conclusions at conceptual level.....	95
4.1.3. Conclusions at SSIP macro-level.....	97
4.1.4. Conclusions at regional level.....	99
4.1.5. Conclusions at the level of the multinational firms.....	101
4.1.6. Challenges on SSIs: towards a phase II?.....	105
4.2. Policy Implications.....	108
4.2.1. The framework of analysis.....	108
4.2.2. On knowledge transfer and development .....	110
4.2.3. On finance transfer and development.....	112
4.2.4. On strategic policies looking at international co-operation and competition. ....	113
<b>5. Dissemination and / or exploitation of results</b> .....	115
5.1. CEPREMAP (Paris) .....	115
5.2. OST (Paris).....	115
5.3. Rotterdam School of Management (Rotterdam).....	115
5.4. TIK (Oslo) .....	116
<b>6. Acknowledgements and references</b> .....	118
6.1. CEPREMAP (Paris) .....	118
6.2. OST (Paris).....	119
6.3. Rotterdam School of Management (Rotterdam).....	122
6.4. TIK (Oslo) .....	129

<b>7. Annexes</b> .....	130
7.1. List and status of the deliverables.....	130
7.1.1. CEPREMAP (Paris) .....	130
7.1.2. OST (Paris) .....	130
7.1.3. Rotterdam School of Management - University of Rotterdam (Netherlands) .....	130
7.1.4. TIK (Oslo) .....	130
7.2. Conference.....	132
7.3. List of Research reports .....	143
7.3.1. List of research report from CEPREMAP	
7.3.2. List of research report from OST	
7.3.3. List of research report from Rotterdam School of Management	
7.3.4. List of research report from TIK	

**Separated Document**

Annex 7.3.1. CEPREMAP research reports

Annex 7.3.2. OST research reports

Annex 7.3.3. Rotterdam School of Management research reports

Annex 7.3.4. TIK research reports

This research focuses on the taxonomy, diversity and recent evolution of the systems of innovation and aims to derive new principles and tools in order to govern science and technology policy in the era of European integration and larger interdependence at the world level.

The first question addressed goes back to the central notion of this study: what a system of innovation is. It is addressed to a broad community of specialists and asks: what a national system of innovation (NSI) does, which institutions it involves, at what level it operates and finally how it performs (Work Package A).

The second question bears on the diversity of national systems observed in Europe and how they fare compare to other very different systems such as the one of Japan (Work Package B).

The third question focuses on the working of NSI at specific levels: the regions and the multinational firms, looking for more information and scope on the conflicting issues that may arise at these levels (Work Package C).

The fourth question then addresses the core issue: what is the impact of economic integration and internationalisation on national systems of innovations (Work Package D).

To improve our knowledge on the very roots of national systems of innovation and on their working it is interesting to focus on such important dimensions, not so much referred to simultaneously, as the regional and the multinational firm perspectives. In both cases specific actors and strategies are at play, which can reinforce or on the contrary weaken the national characteristics of the system. It is an assumption of the project that some points made at these levels can hint at some of the contradictions at work in national systems, which would account for the frequency and the intensity of internal pressure and constraints. All of which are key factors to understand the evolution of the systems, whether it is submitted to external pressure or not.

The conclusions in terms of policy implications point out that the European research area should take into account and build on the features of the EU-Area social system of innovation and production (SSIP) model, features which are shared by EU member states, but in forms which are specific to them. They constitute both constraints and opportunities which are at the root of EU specific comparative advantages in world competition. The socially protective labour regulations can represent advantages in terms of attractiveness and know-how accumulation both in the public and private research and innovation sectors ; income equality is the basis for large demand of high quality goods and services, as well as a potential for skilled labour. We suggest the present challenge is largely to characterise better what could be considered as a European social system of innovation and production and its implications for the European research area in terms of building comparative advantages out of those specificities (at world level), which we share (at EU level).

Yet the risks of divergence that the diversity of European SSIPs contain should not be underestimated and appropriate resources developed to avoid the development of centrifugal forces. The Union in that respect may favour the development of community based institutional schemes in most cases where innovation policies are aiming at some catching up or scratching (what we called the passive innovation policies) in order to avoid a broadening of the gap between countries more inclined to rely on market mechanisms and countries more inclined to rely on national schemes to promote the innovative capability of their economy. In that respect policies aimed directly at the quality of life and welfare of European citizens would be clearly both the best political support and the more effective grounding of economic growth at a time when the decisive step for a durable growth concerns the reconstruction of an “updated and upgraded” effective demand.

### Overall introduction

This research focuses on the taxonomy, diversity and recent evolution of the systems of innovation and aims to derive new principles and tools in order to govern science and technology policy in the era of European integration and larger interdependence at the world level.

Three main avenues are explored :

First of all, the renewed interest for endogenous technical change or neo-schumpeterian analyses has put a strong emphasis upon the role of innovation...but they do not deal explicitly with the network of institutions (organisation of science, incentive for R&D expenditures, industrial relations, tax and credit systems, forms of competition,...) which shape the direction of innovation and the speed of diffusion of technological and organisational advances. This project builds upon the emerging literature on national systems of innovation, in order to propose a theoretically grounded and empirically relevant analysis of the various contemporary configurations. Statistical econometric and institutional analysis will simultaneously be mobilised in order to diagnose the configurations prevailing among OECD countries and some Asian NIC's. This could be a very useful tool for policy makers.

Second, a previous research hints that the 90's might well be a turning point in the competition among the four major social systems of innovation which used to coexist during the 80's. This project digs a neglected question: why and how do systems of innovation evolve? By a close investigation of the internationalisation strategy of the large corporations and a careful analysis of the endogenous transformation of local systems of innovation during the process of European integration, the project intends to enlighten the trade-off between diversity and dynamic efficiency in a more interdependent world. The global structural competitiveness of European Union as a whole will be analysed and a special attention will be given at the recent transformation of Japan and its region of East Asia and its impact upon European specialisation.

Last but not least, this framework has definite consequences for the orientation of S&T and other policies. During the Golden Age, the hypothesis of a catching up with respect to the technological frontier of American mass production was implying that policies should be nearly the same all over the world. Nowadays, the recognition of local idiosyncrasy, sectoral specificity and path dependency of industrial specialisation, calls for a more balanced approach. Given the diversity of local systems of innovation, the same policy may deliver opposite results. Conversely, to warrant an equal dynamism of innovation, different policy objectives and tools have to be developed for each configuration. Along this central message, this project aims to provide new guidelines for policy makers at the local, national or European level.

More precisely, four major issues are investigated.

1. Do we observe a deepening of scientific, technological and/or economic complementarity between the member States belonging to European Union?
2. How far does internationalisation influence the viability of social systems of innovation which used to be largely nationally or regionally based? What is the role of multinationals in this process of diffusion of know-how?
3. How has the competitive edge of EU evolved since the early 90's, by comparison with North-America, Japan and Asian countries?
4. What are the consequences of the expected results for the design of local, national, European policies concerning science and technology? What is the role of networks in the spread of innovation along a supply chain? What new instruments are required to preserve diversity, social cohesion and economic performances?

The first question goes back to the central notion of this study: what a system of innovation is. It is addressed to a broad community of specialists and asks: what a NSI does, which institutions it involves, at what level it operates and finally how it performs (Work Package A).

The second question bears on the diversity of national systems observed in Europe and how they fare compare to other very different systems such as the one of Japan (Work Package B).

The third question focuses on the working of NSI at specific levels: the regions and the multinational firms, looking for more information and scope on the conflicting issues that may arise at these levels (Work Package C).

The fourth question then addresses the core issue: what is the impact of economic integration and internationalisation on national systems of innovations (Work Package D).

Finally, all the previous investigations should converge towards a common aim, that is, to explore the effects of Europe integration and over all internationalisation on the various systems of innovations.

1.1. Conceptual analysis of social systems of innovation and production: what is a system of innovation? (Work Package A)

### **CEPREMAP results and methodology (Bruno Amable, Pascal Petit)**

The notion of 'national systems of innovation' (NSI) has spread beyond the boundaries of the academic world and influenced policy makers in their definition of interventions in the technology policy realm. The main message of the NSI approach is that the institutional context not only influences but also shapes the innovation process and plays a genuine systemic role in technology creation. This has far-reaching implications for the definition and implementation of innovation policy.

### **The limits of the notion of 'national systems of innovation'**

The concept of innovation system (IS) has been the focus of many studies and some papers have already surveyed the field. There are two broad levels of analysis:

- The most basic revolves around a firm and its local environment. Innovation involves complex interactions between a firm, its network of suppliers and customers, and sustained interactions between users and producers of technology. Inter-firm linkages are more important than arms-length market relationships. Institutions affecting the pattern of interactions between economic units are to a large extent national and hence all interactions in the same country will have common determinant.
- The wider context is fairly vague: it refers to broader contexts conditioning innovative activities such as cultural aspects, social customs, national traditions and regulations...

To sum up, one may follow Smith [1998] and give three basic conceptual underpinnings of the IS approach:

- Economic behaviour rests on institutional foundations. The consequence is that different modes of institutional set-up lead to differences in economic behaviour and performance.
- Competitive advantage results from variety and specialisation, it has path-dependence-inducing effects. Successful specialisation are self-replicating, with system creation as an outcome.
- Interactive learning generates technological knowledge. This gives different knowledge bases among different types of economic agents.

The main criticism that we address to the NSI literature is that it stops halfway towards an institutional theory of innovation and production systems. There is no theory of the boundaries of the system taken into consideration but an ad-hoc approach which adapts the frame of the analysis to the special cases under consideration. Most NSI approaches are focusing on the set of activities which are explicitly commonly linked with innovation. But the third point above hints at the fact that this chain may be expanded very broadly indeed! Things tend effectively to become more complicated and open to take into account all kinds of institutions if one counts among the activities involved in the innovation process all kinds of learning processes. Hence the limits of the distinction between narrow and broad definitions of IS put forward by Lundvall whereby:

- the former limits itself to the areas of science, research, technology and in some cases education.
- the latter extends to all economic structures and institutional set-up affecting the production system and innovation.

The vintage *régulation* approach organises the analysis of activities around five sets of relationships: the wage-labour nexus, the forms of competition, international relations, money, and public authorities. The relations between these five forms characterise the overall mode of *régulation* of the economy.

The role of technology in this theoretical set-up is somehow at the interplay between the productivity and demand regimes. It conveys a dynamics of innovation close to that sketched by Kaldor in the description of his cumulative causation model. In that sense it is very specific to a period and a set of countries. Regarding the fordist regime it stresses altogether the development of increasing returns mainly based on scientific organisation of work within large firms and a monitoring of demand by means of new modes of market intermediation, as provided by restructured large service networks. The view it takes of technology is thus more comprehensive than usual as it concerns not only the production processes but also the infrastructures monitoring demand

formation. The drawback is that the very process of innovation seems to be diluted altogether with general matters of organisations on the supply and demand sides.

### **Institutional complementarities**

We argue that the notion of system of innovation and production makes sense only when enlightened by a theory of institutional complementarities. In fact, every systemic view of the modern economies has implicitly or explicitly a theory of complementarity between activities.

The basic hypothesis is therefore that, several institutions -in the broad sense- taken together reinforce each other so that they form a coherent and stable but not everlasting structure. Sticking to a macro point of view, this structure shapes the growth trajectory or the general features of an economy. The aggregate coherence given by a set of institutions is defined by the complementary character of institutions. The concept of complementary institutions is based on multilateral reinforcement mechanisms between institutional arrangements: each one, by its existence, permits or facilitates the existence of the others. Sticking to the static equilibrium defined by a particular structure of institutions, the constraints and possibilities defined by a given institution favour other institutions' functioning. Complementary institutions make one another more or less efficient according to their respective characteristics.

This complementary character is fundamental for defining the coherence as well as the pattern of evolution of an economic system. The 'coherence' of a given system -a 'national' model for instance, defined as the set of interrelated national institutions- is then the expression of the complementarity between specific institutional arrangements and the outcome in terms of economic performance (growth, employment,...).

### **Dynamics of systems of innovation and production**

The notion of institutional complementarities links together different institutions and modes of organisation in a certain architecture. A notion of *hierarchy* of institutions insists on the relative importance of one or a few institutions for the architecture as such. In a static perspective, hierarchical relationships define a link between institutions and should therefore be explored starting with the different kinds of complementarities that we have distinguished.

Such seems to be the case regarding the innovation capability of a country. The central role of this capability in determining the competitiveness of countries helps to suggest that institutions supporting the dynamics of innovation can somehow be copied and transferred. Our argument stresses that such reverse engineering could be very misleading if one did not take into account the various complementarities conditioning both the implementation and the impact of institutions.

## 1.2. Structure and stability of systems of innovation in 22 countries (Work Package B)

1.2.1. OST research results and methodology on typology and dynamics of Social Systems of Innovation and Production (SSIP) : what perspectives for the European Research Area ? (Rémi Barré, Yann Cadiou, Françoise Laville, Sandrine Paillard, Sandra Petit)

### A. Objectives

The operational objective is to update and extend a taxonomy for social systems of innovation and production and characterise their dynamics :

1. to survey a large number of possible SSIP parameters and select them in terms of the availability and quality of data,
2. to establish a typology of SSIP and characterise different types, thus re-visiting the previous taxonomy of social systems of innovation established by Boyer, Barré, Amable [1997],
3. to provide a dynamic perspective for these SSIP over the period 1986 - 96,
4. to deepen the analysis by explaining the overall structure, typology and dynamics by the role of various sub-systems.

B. Method: survey of possible SSIP parameters and selection in terms of the availability and quality of data, data analysis performed

The approach consists in data analysis and clustering for various sub-systems. The analysis concern 22 countries from Europe, North America and Asia at three dates (1986, 1991, 1996). Few data satisfied the criteria<sup>1</sup>, and in fact only 64 variables could be finally selected.

The sub-systems and the variables : after review of the available and relevant data, we break up the SSIP in eight sub-systems:

1. volume and funding of R&D activities
2. scientific specialisation
3. industrial R&D profile
4. technological specialisation
5. economic activities profile
6. labour market and social protection
7. education
8. macroeconomic and social performance

The SSIP of the countries are described by 64 parameters for years 1988 and 1996.

The typology results from a clusterisation of the countries built on the distances between each pair of countries.

#### c. Result 1: typology of the Social System of Innovation and Production (SSIP) of 18 countries identifying a EU-Area SSIP model static analysis (year 1996)

The typology results from a clusterisation of the countries built on the distances between each pair of countries. The countries are split into 7 groups. Each group is said to be an SSIP 'type'. Each group / type is given a label of geo-political nature (table 1).

Table 1 – the geopolitical labelling of the seven SSIP types

SSIP type	countries	Geopolitical label
1	Australia, Norway	Natural resources
2	United-States, United-Kingdom, Canada	Anglo-Saxon
3	Belgium, the Netherlands, Denmark	EU-North sea
4	Finland, Sweden	EU-Nordic
5	Germany, France, Italy, Austria	EU-core
6	Japan	Japan
7	Spain, Greece, Portugal	EU-Mediterranean

#### Characterisation of the seven SSIP types

**Natural resources (type 1)** has a rather low innovative activity and financing of RD by the business sector. This group has strong medical research and earth (geology) – ocean scientific specialisation. The structure of economic activities is characterised by a large share of services .

The education sub-system exhibits a large public expenditure on education per capita and as % of public expenditure, as well as a high level of graduates of the university tertiary level. Type 1 has a high level of GDP per capita.

**Anglo-Saxon (type 2)** is characterised by rather strong RD activities. However, the number of invented patents relative to GDP is relatively weak. The scientific specialisation is in life sciences and earth-ocean-universe sciences. A high share of services in GDP characterises the structure of economic activities.

On the labour market, the rate of union membership, seniority superior to 20 years and expenditures for unemployment are low whereas the precariousness feeling is strong. The education sub-system is defined by a high level of graduates at university level. GDP per capita is high and income distribution is unequal.

**EU-North sea (type 3)** has an average level of RD activities. Its scientific specialisation profile is dominated by biology and medical research. It has a rather large share of services activities, but relatively modest ones regarding industry.

<sup>1</sup> some data were missing for Switzerland, Luxembourg, Korea, and Ireland

The labour market sub-system exhibits a rather high rate of union membership. On the education side, this type is characterised by large public expenditure on education per capita and graduates of the university tertiary level. GDP per capita has an average level and income distribution is rather egalitarian.

**EU – Nordic (type 4)** is characterised by a high level of both public research and industrial research and innovative activities. Its scientific specialisation profile is dominated by biology and medical research. The structure of economic activities is characterised by large shares of Industry and Equipment goods sectors. The labour market sub-system is defined by a large rate of union membership and expenditure for unemployment. On the education side, public expenditure on education per capita is very high. GDP per capita is average and the income distribution is egalitarian.

**EU-Core (type 5)** has an average RD activity. It is specialised in chemistry, physics and mathematics. The structure of economic activities exhibits a high share in the equipment goods sector. Education shows relatively low levels of graduates of the university tertiary level and public expenditure on education as % of public expenditure, but the level of graduates of the upper secondary level is strong. This type has average values as far as GDP per capita and income repartition are concerned.

**Japan (type 6)** is characterised by high level of innovative activities in the business sector. (high level of financing of GERD in the business sector). Its scientific specialisation is dominated by physics and chemistry. The structure of economic activities is characterised by weak shares of both Services and Agriculture, high shares of Industry, especially the Electronics and Equipment goods sectors. Seniority superior 20 years is high. Higher education enrolment and Public expenditure on education as % of public expenditure are weak. GDP per capita has a high level.

**EU-Mediterranean (type 7)** is characterised by weak research and innovation activities. Its scientific specialisation profile is strong in engineering sciences, mathematics and chemistry. The economic activities structure exhibits a high share of agriculture, a low share of both services and electronics and equipment goods sectors. On the labour market side, this type has a very weak rate of union membership. Education variables are all at a low level. GDP per capita is low and income repartition is rather unequal.

#### **Relating the seven types to the SSIP models defined in Amable, Barré, Boyer (1997)**

Considering the four models defined in Amable, Barré, Boyer (1997) as relevant archetypes, we relate the seven types to these archetypes considering the distances among the seven types (table 2).

Table 2 - interpretation of the seven types in terms of the four SSIP models defined in Amable, Barré, Boyer

<b>SSIP model in Amable, Barré, Boyer</b>	<b>SSIP type</b>	<b>countries</b>	<b>Geopolitical label</b>	<b>SSIP model and their variants</b>
Public institutions based	5	Germany, France, Italy, Austria	EU-core	public-institutions-based model
	3	Belgium, the Netherlands, Denmark	EU-North sea	variant of the public-institutions-based model for very developed countries of rather small size and strong internationalisation
	7	Spain, Greece, Portugal	EU-Mediterranean	variant of the public-institutions-based model for less developed countries, but with many specific features
Social-democrat	4	Finland, Sweden	EU-Nordic	social-democrat model, getting closer to the public-institutions-based model
Meso corporatist	6	Japan	Japan	meso-corporatist model, getting closer to the public-institutions-based model
Market based	2	United-States, United-Kingdom, Canada	Anglo-Saxon	market based
	1	Australia, Norway	natural resources	variant of the market based model for economies heavily determined by the exploitation of natural resources

D. Result 2 : characterisation of the SSIP of the EU member states - An EU-Area model ?

EU countries appear in 5 of the 7 groups which is an indication of the diversity of the EU nations innovation and production systems. However, the groups of Japan (group 6), the USA, Canada (group 2) and Australia, Norway (group 1) are not positioned in-between EU-nations groups, but at the periphery of the first factorial plane. This means that on the whole, EU member states have more in common among themselves than with non-EU nations. In other words, EU member states are diverse, but they share some key-features, the UK having here a specific situation.

Table 3 – the types in terms of broad models, including a tentative EU-Area model

<b>Broad model reference</b>	<b>type</b>	<b>countries</b>	<b>geopolitical label</b>	<b>SSIP model and their variants</b>
<b>EU-Area model (public institutions based model broadly defined)</b>	5	Germany, France, Italy, Austria	EU-core	public-institutions-based model
	3	Belgium, the Netherlands, Denmark	EU-North sea	variant of the public-institutions-based model for very developed countries of rather small size and strong internationalisation
	7	Spain, Greece, Portugal	EU-Mediterranean	variant of the public-institutions-based model for less developed countries, but with many specific features
	4	Finland, Sweden	EU-Nordic	social-democrat model, getting closer to the public-institutions-based model
<b>meso corporatist model</b>	6	Japan	Japan	meso-corporatist model, getting closer to the public-institutions-based model
<b>market based model</b>	2	United-States, United-Kingdom, Canada	Anglo-Saxon	market based
	1	Australia, Norway	natural resources	variant of the market based model for economies heavily determined by the exploitation of natural resources

What do the EU member states have in common ? what makes the EU-Area different from the others ?

The EU member states share key features in their SSIP, allowing us to define a broadly defined EU-Area SSIP model, having much to do with the public institution based model.

The EU member states SSIP share almost all the parameters of labour market – social protection sub-system, as well as a relatively evenly distributed income and an important role of government services in GDP. They also share:

- a relatively important role of industry in economic activity,
- a high proportion of national industrial RD in automobile, chemistry, equipment goods,
- a scientific specialisation in physics and chemistry.

In brief, EU-Area SSIP are all characterised by significant redistributive functions aimed at social objectives and public services, particularly in relationship with the labour market. They are also all characterised by the importance of ‘classical’ industrial sectors (such as automobile, chemistry, equipment goods) and the intensity of their innovation activities in those sectors.

**Nevertheless, the EU-Area SSIP model has variants related to substantial differences**

EU member states SSIP differ on GDP per capita and rate of unemployment, on all parameters of sub-system volume and funding of RD activities, and on most parameters of sub-system education activities.

They also differ in their:

- proportion of agriculture and of electronics sector in GDP,
- proportion of national RD in labour intensive sectors,
- level of technological specialisation in electronics, as opposed to household consumption goods,
- level of specialisation in biology and medical research, on one side, in engineering and mathematics, on the other.

Such differences are important enough to raise questions on the dynamics of the variants, as well as the conditions of a European research area.

### **What is the impact of economic integration and internationalisation ? What significance for the emergence of a European Research Area ?**

1. The dynamics of the social systems of innovation and production: a mix of common trends and specific divergence aspects ; on the whole, no overall convergence among SSIP types

- A common trend among all social systems of innovation and production (SSIP) is move towards what can be called the knowledge society: the parameters concerned are the development of higher education enrolment, increased public and private RD and S&T activity, larger share of business services, biotechnology and ICT in economic activity. These parameters involve no significant phenomena of catch up, which make them neutral vis-à-vis the convergence – divergence problematic.
- Some parameters exhibit a divergent dynamics among SSIP types: such is the case of those related to social protection and labour regulation, as well as income distribution. These parameters result in increased EU-types similarity, but in overall divergence if one includes non-EU SSIP types. The hypothesis of ‘convergence clubs’ among SSIP types can be put forward.
- These findings tend to validate the hypothesis that:
  - a variety of institutional configurations governing technical change may exist, produced by history in a process that owes more to trial and error than to perfect rationality,
  - this particular type of path dependence questions the relevance of the idea that all countries converge towards the same technological (and institutional) model.

2. The relative performance of the SSIP types: diverging achievement on income distribution, but no systematic nor significant differences in achievement on productivity and employment

The question is to know whether or not in the 90s a shift occurred in the relative performance of these SSIP types. The hypothesis is that changes in the determinants of competitiveness as well as the development of world wide markets and an extended internationalisation of production processes could well have eroded the links of SSIPs with performance.

Our findings lead us to differentiate among the various aspects of the performance of a SSIP.

Regarding the equity aspect (income distribution evolution), SSIP types have clearly differing achievements, i.e. the EU-types perform systematically better. Regarding achievement in productivity and employment, no systematic nor significant differences among SSIP types have been found.

3. There are good reasons to consider there exist a EU-Area SSIP model: on the whole, EU-SSIP types have similar socio-institutional context of social protection and labour sub-system, as well as mature industrial sectors capabilities.

- There are wide EU SSIP types differences in terms of absolute level of activity and specialisation on many parameters. But the EU SSIP types have several key-features in common, which make them different. We call EU-Area SSIP model this broadly defined set of types, considered as variants of the model.
- EU SSIP types also have similar dynamics, which tends to validate the notion of the EU-Area SSIP model: same trend towards the knowledge society (common to all SSIP types), same reinforcement of their key features, in particular social protection and labour sub-system (specific to the EU SSIP types).

4. The role of EU integration in the dynamics of the EU SSIP types: process which is helpful – sometimes crucial - for member states to catch the world-wide common trends (knowledge society) and to develop EU specific trends (social protection and labour regulations)

EU integration is, in our view, a major factor for such parallelism both regarding entrance in knowledge society and the institutional context, in particular regarding social protection and labour regulations.

Our point is not that without European integration EU SSIP types would have necessarily diverged. We simply suggest that EU integration is a process which is helpful – sometimes crucial - for member states to catch the world-wide common trends (knowledge society) and to develop EU specific trends (social protection and labour regulations).

5. The building of a European Research Area: dealing with world wide trends, EU-Area SSIP model specificities and the EU SSIP types diversity.

- First, the European research area must be in coherence with world wide trends in terms of the advent of a knowledge society, which means an increase in the volume of a number of activities (S&T, RD, higher education ...),
- Second, the European research area must take into account and build on the features of the EU-Area SSIP model: such features are shared by EU member states, but are specific to them. They constitute both constraints and opportunities which are at the root of EU specific comparative advantages in world competition. The socially protective labour regulations specificities can represent advantages in terms of attractiveness and know-how accumulation both in the public and private research and innovation sectors ; income equality is the basis for large demand of high quality goods and services, as well as a potential for skilled labour. We suggest the present challenge is largely to characterise better what could be considered as a European social system of innovation and production and its implications for the European research area in terms of building comparative advantages out of those specificities (at world level), which we share (at EU level),
- Third, the European research area must deal with the diversity of the SSIP of the EU member states. There are two kinds of diversity to be considered:
  - a) the diversity among variants of the EU Area SSIP model, which are basically differences in degree of development, or differences due to size of country or geography ; such is the case of almost all EU members,
  - b) the diversity among SSIP models within the EU, which so far concerns only the United-Kingdom. This relates to differences in essence and fundamental functioning principles of the SSIP.

The diversity in degree can simply be dealt with through market-regulated complementarities among systems having roughly the same procedures, references and logic. Integration can largely be an autonomous dynamics.

The diversity in essence cannot be integrated in a common 'area' through automatic – decentralised mechanisms such as the market. Specific compromises of institutional nature have to be negotiated and implemented so as to ensure internal coherence and intelligibility to the system.

Of course, this may be painful and difficult, but the potential benefits are high, since it would give the EU a strategic advantage of being able to play the competitive game in a variety of settings.

The diversity problematic should lead to special attention to the EU-Mediterranean, to the EU-Nordic and to the UK SSIP types. For various reasons, they all represent high potential, and possibly high risk, assets for the EU as a whole.

### 1.2.2. TIK results and scientific activities

#### A. Technological Progress, Structural Change and Productivity Growth: A Comparative Study (Jan Fagerberg and Tao Zhang)

The objective of this sub-project was to analyse in depth some of the challenges arising for Europe from developments elsewhere, the evolution of Asian economies in particular.

#### **Methodology.**

The sub-project focuses on the relationship between specialisation, structural change and productivity growth in manufacturing in recent decades. The perspective is similar to that of Salter (1960) in the sense that we analyse the manufacturing sector as composed of a number of different industries. However, we share with Denison (Denison 1967, Chung and Denison 1976) the comparative approach to studies of economic growth: the present sample includes 39 market economies (on different levels of development) between 1973 and 1990, basically all countries within this category for which data are available.

#### **Scientific Findings.**

The results indicate that structural change still matters, but in a different way than before. The main difference concerns the role played by new technologies in generating structural change. In the first half of the 20th century, growth of output, productivity and employment were strongly correlated. Employment in industries based on new technologies (such as electricity and synthetic materials) expanded rapidly at the

expense of more traditional industries, implying an important role for structural change in explaining overall productivity growth. More recently this relationship between output, productivity and employment has become more blurred. New technology, in this case the electronics revolution, has expanded productivity at a very rapid rate, particularly in the electrical machinery industry, but without a similarly large increase in the share of that industry in total employment. In fact, the industries that increased their role in total employment most substantially were generally traditional industries – mostly geared towards private consumption - with average to low productivity growth. Hence, in recent decades, new technology has not been linked with structural changes in demand, output and employment in the same way as before. This explains why structural change - in a pure accounting sense - was more important for productivity growth previously than it appears to have been more recently (at least up to 1990).

However, this does not mean that the electronics revolution - or the structural changes associated with it - have not been important for overall productivity growth in the period under study.

First, the electrical machinery industry (which is the industry most intimately related to the electronics revolution) has experienced much higher productivity growth than any other industry, implying a growth bonus for countries with a superior performance in this industry.

Second, there have been important spillovers to productivity growth in other industries, and available research indicates that these have been stronger at the local or national level than globally. Hence, the results presented in this paper suggest that countries that during the period under study here managed to establish themselves firmly in the electronics industry got a sizeable growth bonus from these investments.

### **Conclusions and implications**

Finally, the comparative study on technological progress, structural change and productivity growth focuses on the impact of specialisation and structural changes on productivity growth in manufacturing, using a sample of 39 countries and 24 industries between 1973 and 1990 and shows that while structural change on average has not been conducive to productivity growth, countries that have managed to increase their presence in the technologically most progressive industry of this period (electronics) have experienced higher productivity growth than other countries.

This being said, it seems appropriate to issue a warning regarding the possible implications of these findings. First, leading technologies – and the industries most affected - change through time, and so do the conditions for entry and the rewards from it. Thus, the relevant policy conclusion to draw from this is not that every country should move into production of electronics as fast as possible. Rather, the lesson is that there may be important potential gains to overall growth and – possibly – welfare from successful entry in technologically progressive industries that should be taken into account when designing policy. Second, little is said here about what the conditions for such entry were during the period under study or – of even greater importance for policy - are likely to be in the future. Arguably, these questions deserve a high rank on the future research agenda in this area.

#### **B. Japanese policy initiatives at the national and corporate levels (Terje Grønning)**

The objective of this sub-project was to contribute to the analysis of some of the challenges arising for Europe from developments elsewhere by way of placing particular attention on selected aspects of the evolution of the Japanese economy. In concrete terms this meant to gain increased understanding of (a) policy initiatives at the national and corporate levels and (b) R&D/innovation activities as they are undertaken by selected Japanese firms.

### **Methodology**

The chosen methodological approach was discourse analysis applied to policy initiatives, supplemented with a survey of the wider context and aftermath of each of the policy initiatives. We constructed for analytical purposes an ideal type of the institutions and the institutional elements of what has been understood as constituting the Japanese employment system thus far, and subsequently assess the Federation's policy in relation to this ideal type in order to investigate the degree of continuity versus advocated change.

### **Scientific Findings.**

Recent studies collecting and assessing Japanese empirical data have stressed that there is a strong degree of continuity in spite of a radically changed business environment. Compared to this stress on continuity, the

policy initiative under scrutiny is in overall advocating a break regarding a number of the institutions. Most notably this concerns the rearrangement of the labour market at large into three segments, as compared to the two segments of the current labour market. These radical recommendations have, however, hitherto been met with resistance from a number of other social actors, including labour and leading academics.

### c. Multinational R&D, Corporate Organisation and Innovations Systems: A Study of the Domestic and European R&D-activities of the Japanese Speciality Chemicals Industry (Terje Grønning)

The objective of this sub-project was to contribute to the analysis of some of the challenges arising for Europe from developments elsewhere by way of placing particular attention on selected aspects of the evolution of the Japanese economy. In concrete terms this meant to gain increased understanding of R&D/innovation activities as they are undertaken by selected Japanese firms.

#### **Methodology.**

The sub-project focuses on a specific aspect of dynamics, i.e. the way a certain type of actors may or may not be influencing the evolution of particular innovation systems.

The study proceeds by synthesising three different types of approaches: firstly, the frameworks developed within international business studies regarding the notion of centripetal versus centrifugal forces which may influence the decision to locate R&D in a particular location (Bartlett & Ghosal, 1990), secondly frameworks developed within sociology, economics and organisation studies regarding institutions and institutionalisation processes (Westney, 1999), and thirdly approaches regarding the make-up of different types of innovation systems (Lundvall, 1992).

#### **Scientific Findings.**

Although the study is not able to answer directly any questions regarding specific causalities regarding the relationship between MNE-activity and particular innovation systems' dynamics, it does, however, illuminate the mechanisms behind a transition from a domestically based state of affairs to a state where the enterprise conducts its R&D (including high-value added R&D) on a multinational basis, and hence relates to several innovation systems simultaneously, including the domestic one. Within the two sectors studied the first overseas establishment was in 1985, there were still hardly any facilities abroad at all a decade ago, whereas there are currently more than thirty. This development has occurred during the same period that the Japanese economy has struggled with difficulties. Here we review the findings in terms of reasons for establishing the overseas units in the first place and the countries where they are located.

The enterprises which were studied have a preference for particular countries and regions. There are as many facilities in Europe as there are in the US, but there is a majority of basic research units located in the US when in seen in comparison to Europe. Within Europe there are two printing inks and four pharmaceutical laboratories located in Germany, whereas there are no printing inks and ten pharmaceutical laboratories located in the UK. The only other countries which is represented are the Netherlands and France, with respectively one pharmaceutical facility and one printing inks European headquarters and manufacturing facility which includes some research and development.

### 1.3. Specific crossed perspectives on systems of innovations: the regional and multinational firm levels (Work Package C)

#### 1.3.1. Rotterdam School of Management (Erasmus University) research and results on multinationals and systems of innovation: towards an international interactive perspective (P. Beije, D. van den Berghe, P. Boekholt, A. Brechje, M. Lankhuizen, R. van Tülde, A. Wulff)

##### A. Introduction: interaction in innovation as an international race

Innovation has become an increasingly international and interactive process. Interaction can thereby take many forms:

- Interaction between teams/persons within the same company;
- 'extra-mural' interaction of company R&D laboratories and networks/clusters of other firms and actors;
- interaction between countries and their governments in the formulation and implementation of innovation policies;
- interaction between internationally operating firms that decide upon the spread or concentration of their innovation activities;
- interaction between governments and firms.

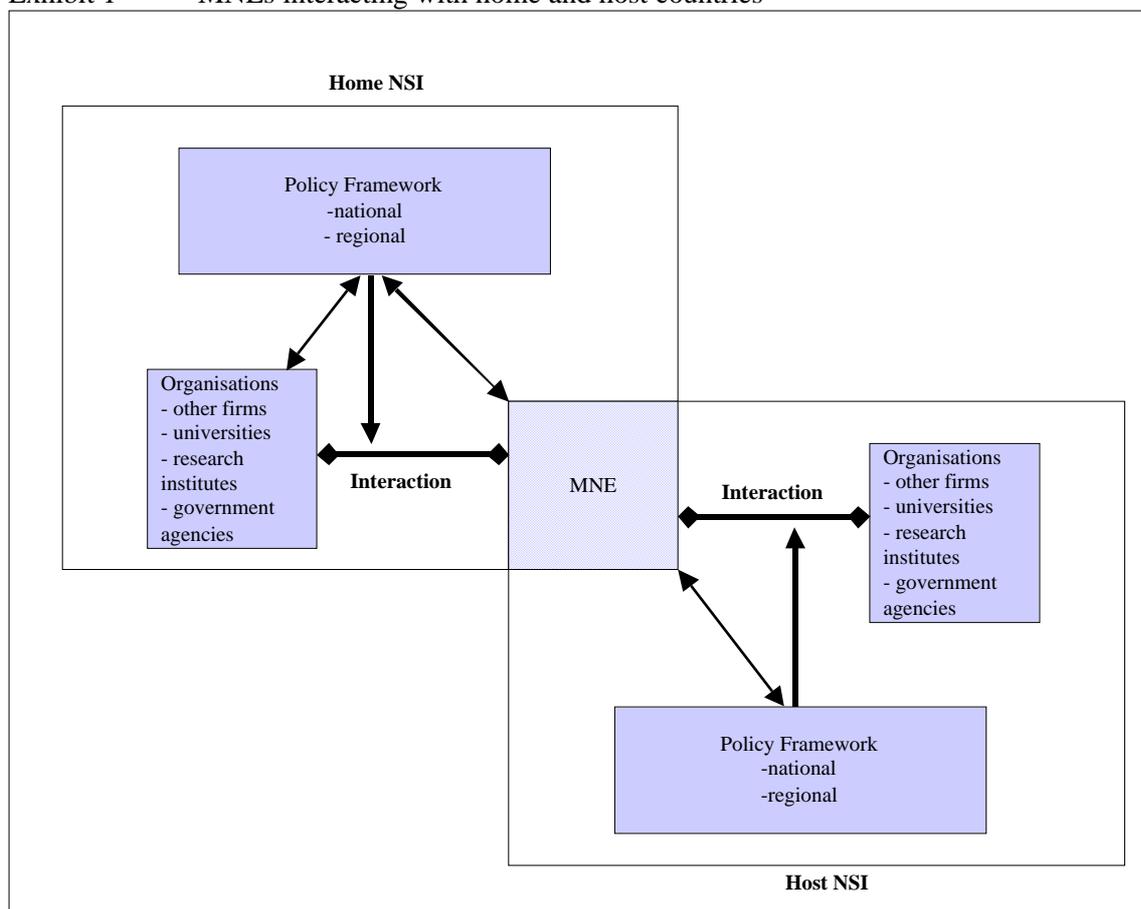
On the surface the international innovation race therefore does not seem to have intensified. But in the 1990s, the shift of the actors in the race has been from governments to firms. How many actors are important in shaping the international interaction? Are we talking in a game-theoretical perspective of a multiple-actor game or one in which there are only a limited number of players (a “small numbers” game).

B. Leading research questions

Integrating the strategic perspective of multinational corporations and their R&D strategies with the perspective of (national) systems of innovation is a new endeavour. This study therefore provides a first attempt in tackling the relevant questions. Leading questions that guided the research project have been:

- Does the National Systems of Innovation literature take into account the strategies of leading companies? In addition: does the NSI literature take into account the international dimension in general and the strategies of multinational companies in specific? Does it make a difference whether NSIs are ‘closed’ or ‘open’ and include ‘home’ or ‘host’ companies?
- Can the NSI framework be conceptually and politically expanded to include the multinational perspective or is a completely different framework required?
- What relevant trends can be observed in the strategies of leading companies: centralisation, decentralisation of R&D or something else; do national origins of firms still matter?
- What are the consequences of the interaction of governments and of leading corporations (that are partly international) for the effectiveness of policy making.

Exhibit 1 MNEs interacting with home and host countries



The study is intended to cover the dynamic interaction between (national) systems of innovation and multinational firms, which is graphically illustrated by exhibit 1.

Exhibit 1 is a simplified figure. In the presentation of exhibit 1, a single Multinational Enterprise (MNE) is the focal actor, whereas the National Systems of Innovation are categorised as ‘home’ or ‘host’. The prime unit of analysis is the multinational corporation. UNCTAD (1999) studies reveal that at the moment around

50.000 multinationals exist (from an assessed 7.000 in 1970) co-ordinating more than 300.000 subsidiaries around the world. So each MNE co-ordinates a number of activities over host and home countries. Their strategies are based upon an internal dynamism, but also on a competitive logic in which they respond to the actions of other firms. The focus of the analysis can also change, by choosing a national focus. This analytical angle will also be used, in which case the relevant distinction becomes between 'home firms' and 'host firms'.

#### c. Part One

##### **International/interactive innovation.**

The NSI literature distinguishes various types of *organisations* such as firms, universities, research institutes, and government agencies. This is inherent to the notion of innovation as an interactive process. Yet, the level of analysis is too aggregate to segment different types of firms. Consequently, the NSI literature has little to say about how MNEs affect the performance of NSIs. Only Chesnais (1992) has attempted to deal with MNEs in NSIs. Chesnais aims to discuss the possible impact of foreign direct investment (FDI) on the structure and the organisation of NSIs. However, Chesnais does not identify exactly *how* MNEs influence NSIs.

##### **Diverging trends in international R&D organisation.**

A number of trends were identified, that to a certain extent run contrary to each other:

- an increase in the number of R&D units abroad since the 1980s, albeit using different modes of establishment of R&D units;
- an increase in the degree to which such foreign R&D units are embedded in local NSIs;
- and more recently a trend back to a re-centralisation of R&D by some firms in the home NSI.

#### d. Part Two

##### **International R&D organisation: mixed trends.**

The relevant distinction becomes between 'home' and 'host' *countries*. The R&D, innovation and patenting strategies of different sets of leading/core companies are observed. Their strategies concerning the international organisation of the R&D and invention

Respondents in interviews (including the interviews held for this research project) generally bring forward that R&D is internationalising. On the basis of the evidence above this impression can not be unequivocally substantiated. There is no increase in international R&D expenditures for all firms, in all sectors and/or for all countries. Major differences between firms, sectors and countries remain. From the comparison between 'total Tni' and 'R&D Tni' a strong relationship could however be deduced: the internationalisation of R&D strongly correlates with the internationalisation of total corporate activities. The general feeling amongst respondents might be that the internationalisation of companies is increasing and thus – due to the above correlation – the internationalisation of R&D. For large parts of the first half of the 1990s, this was indeed true. UNCTAD's World Investment Report (in collaboration with the Erasmus team) noted increasing levels of TNI in the first half of the 1990s. Paradoxically, the trend for the following years seems reversed. Since 1996, the most international firms (as measured by their internationalisation of assets) show a trend of a *declining* TNI (UNCTAD, 1999; 2000). This decline is partly due to the Asia crisis and a perceived increase in instability in the international financial system, and to the increased regional dynamism due to stepped regional integration processes. Would this process therefore also lead to a declining R&D TNI? It seems more probably that the decline in TNI will only after a time-lack be accompanied by a comparable decline in R&D Tni. But this recent development clearly deserves further research.

The evidence on the internationalisation strategies of firms remains mixed. Companies centralise as well as decentralise certain R&D-related activities. The more international companies are, the more they have also internationalised their R&D. But the countries over which they spread their innovation activities (including the sourcing of inventions) remains relatively limited and often restricted to *neighbouring* countries. The number of international (European) patents has tremendously increased, which confirms in any case a trend toward a more regional innovation system. In documenting the international innovation strategies of groupings of important multinationals and/or core companies, it is shown that the home-base still matters. Companies want to exert control over their innovation process, which amongst others resulted in a rather strong degree of control over the ownership of patents. National patterns were quite obvious illustrating the

importance of national institutions for the functioning of the core players (and thus for the NSI). It is not sure that this will lead to the claimed increasing interdependence of R&D laboratories spread around the world.

#### **NSI-MNE interaction: home/host country matters.**

The various manners in which specific MNEs interact with *specific* NSIs are analysed. NSIs differ from one country to the next. The way in which organisations involved in research and technological development – like universities, research institutes and firms – act and interact, differs between countries. Moreover, the way in which the S&T infrastructure interacts with public policy differs too. The role of MNEs differs from one country to another as well. As a result, the impact of R&D strategies of MNEs, in particular their internationalisation strategies, will differ between countries. The typologies of NSIs that were developed in chapter four are tested in this chapter: the distinction between five countries sharing a different (ideal type) relationship with home and host MNEs is relevant.

#### E. Conclusions at the level of the multinational firms

The study at the level of the multinational firms has established that multinational companies play a key role in national systems of innovation. Their share of total spending on R&D in most countries is so significant that a radical change of these companies' strategies will be felt throughout the system. The intensity of their interaction with other parts of the system varies from country to country, but inter-firm relations as well as collaborations with the public research infrastructure is eminent. In this sense the actions of multinational should be a prime policy concern for both small and large countries.

As a consequence nationality still matters. Firm nationality - and thus the distinction between home and host system of innovation/country - still matters in at least three ways:

- In most countries the bulk of the R&D expenditures is still performed by national (home-based) firms. The UK seems to become an exception.
- The internationalisation patterns of innovation (in both patenting and R&D organisation) often reveal more distinct national than sectoral or size-specific characteristics. This corroborates the idea that the home-base influences the properties of the internationalisation strategies of MNEs in quite distinct manners (Cf. Whitley, van Tulder/Ruigrok). As a consequence, interactive innovation with a subsidiary of a Japanese, German or American company reveals also distinct characteristics. Patenting strategies for instance reveal varying degrees of centralisation and control. National styles of multinational companies exist.
- There are still clear differences in the R&D strategies (including R&D intensity and the nature of the R&D function) of 'home' and 'host' firms inside national innovation systems. An exception seems to be the Netherlands, where host multinationals seem to share comparable characteristics as most of the home multinationals.

Size still matters. R&D is a small numbers' game, the dynamism of interactive innovation consequently often depends on the interaction of only few big players. Critical mass is important for firms to locate activities somewhere. Firms themselves require critical mass, partly also because governments have lowered their relative expenditures in R&D. Weakly developed NSIs therefore will never attract really high-end parts of the R&D organisation of host-based multinationals.

The prevalence of national patterns, combined with the lack of real supra-national institution should make the fear of policy makers that their home-based firms could become completely 'footloose' not justified. Investments in R&D abroad are mostly additions to home-based R&D activities and not a replacement. Nevertheless, MNEs are very well aware of the political sensitivity of this issue and therefore cautious to reveal their long term plans for shifting the geographical focal points of their R&D activities.

MNEs still value proximity in collaborating with other parts of the innovation system.

The qualitative part of our study showed that MNEs value to work with research organisations in their region or in not too far distance from their headquarters. However there were some clear trends coming out this part of the research that might weaken this current approach in the future:

- The quality of research in the home country has to be high enough to at least keep up with international state-of-the art. Some concern was expressed relating to the deterioration of the science base and the lack of highly qualified staff to perform this.

- MNEs are finding their ways to research excellence regardless where in the world. Although the headquarters of corporate research are not being relocated, specialised research centres in particular technologies are established in those areas that can offer the skills and knowledge. Particularly in the newer technology areas, the regional specialisation patterns are still moving and therefore R&D strategists with MNEs will keep an open mind to where to locate specialised research units.
- MNEs stated that their collaboration with the public research infrastructure is oriented more towards fundamental-strategic research than towards applied problem solving research. Applied research, particularly when it is closely connected to the companies' core business is done in-house and not shared with external parties. It is in fundamental research where MNEs seek complementary expertise, particularly to stay informed about a range of technological options for the future. On the other hand we see a trend in Europe that universities are encouraged to move towards more applied and market – near research and to play a more active role in helping industry to innovate. From the perspective of MNEs this trend would make the public infrastructure less interesting since the complementarity with their own knowledge base is diminishing. The policy conclusion is that in order to embed MNEs in the national system of innovation, investments in basic research are an indispensable element of a healthy system. This does not imply a move back towards mono-disciplinary, blue sky research, but interdisciplinary fundamental research that fits the 'Mode II' model.
- The main bottleneck from the perspective of MNEs, is the cultural gap between the universities and the logic of their business enterprise. Particularly in Germany, and to a lesser extent in the Netherlands and UK managers of MNEs perceive the universities as organisations that stand too far away from the needs of commercial enterprises. There is still a reluctance to perform research with a commercial focus, the bureaucratic regulations do not allow an efficient collaboration and often senior staff are not willing or allowed to collaborate in projects. From the perspectives of multinationals the research-industry interfaces are not functioning well enough, despite many policy attempts to improve this relationship. This calls for a re-orientation of present policy efforts on industry-research interfaces. We have to note that policy should address a wider industrial community, than the MNEs alone. Different target groups from the business sector will need different interfaces.

In many cases R&D settlements follow the location of manufacturing sites. Nevertheless given the fact that some MNEs are clearly moving towards decentralisation of the R&D functions within the corporation, there is more room for specialised R&D labs in areas that have proven to provide knowledge excellence and skills in given technologies. This would support the European policy approach to promote 'centres of excellence' that have a clear international profile as world leading in their area of science. Having acknowledged centres of excellence would attract and embed R&D investments not only from European MNEs but world wide.

An important partner in outsourcing R&D, in particular pre-competitive R&D appeared to be the high-technology start-up companies. In comparison with the more formal public research infrastructures these are highly specialised and commercially oriented organisations that provide knowledge near to the core areas of the MNEs. Having a large pool of these high-tech start-ups in a national system of innovation would make its fabric more attractive for R&D investments by MNEs. The policy implication is that the promotion of leading edge start-ups would add to the attractiveness of a national system of innovation. Germany has been very active in supporting this business start ups and new regional technology networks are arising from business ventures in areas such as nano-technology, information technology and bio-technology. In the UK this area has been picked up by commercial venture capital initiatives and entrepreneurial universities. The Netherlands and Ireland are late comers to this area and are only just launching initiatives in some technology areas.

Having a highly qualified workforce relevant for their most strategic functions (R&D, marketing, finance) is the key asset for MNEs. This means that good universities are an important recruitment pool for skilled staff and particularly research personnel. The education function of universities are often as important as their research capabilities. There was concern in some countries (Netherlands, Ireland) that the quantity of graduates is not sufficient to satisfy skills requirements in those countries particularly in the hard sciences and engineering. In policy terms this means that actions should be launched to address the shortages in these specific areas.

The protection of Intellectual Property Rights was only a prominent issue for companies active in the life sciences. Here a restrictive ethical and legal framework to develop new technologies influenced investment

decisions in favour of areas with fewer restrictions. A closer European co-ordination on these issues would prevent that national governments compete on this issue, at the cost of the quality of life of some Europeans. In Germany the debate on ownership of patents was an issue for debate for MNEs, since ownership is spread over as many individuals as have contributed to a certain research result. This was considered to hamper the negotiations on license agreements between companies and research organisations. Some European guidelines on how to deal fairly with the patent licensing could improve the exploitation of research.

In relation to the specific national systems of innovation the main conclusions depend on the role of home-based versus the host-based multinationals.

Summarising, research excellence and a highly skilled workforce are the key assets on the basis of which both home-based and host-multinationals make their R&D investment decisions. For national policy makers this means that to tie home-based MNEs as well as attract foreign MNEs, a permanent upgrading the quality of the national system of innovation and its people.

### 1.3.2. OST results and methodology on S&T Co-activity in Regions : an Insight in the Geography of the Knowledge-based Activities in EU (M. Zitt, S. Ramanana-Rahary)

#### A. Context and objectives

The aim of the project is to study the potential of regions, in Europe, from the point of view of the "knowledge-based society" where economy (labelled 'E'), technology (labelled 'T') and science (labelled 'S') combine. The idea of virtuous circles of interactions between the three activities has given rise to many works in spatial economics, regional economics, technical change studies. A central hypothesis is the existence of spatial scientific externalities, stating that the industrial firms, especially those committed in technological R&D (and among them multinational firms), draw advantages from the presence of nearby academic centres.

The operational objectives of this study are :

- a) to build a typology of regions, in Europe, from the point of view of their commitment in the two dimensions of the knowledge-base society.
- b) to roughly assess the potential of localised S-T spillovers or transfers in regions, through an insight in co-locations of science and technology (empirical co-location, whatever the causes).
- c) a step further, to investigate regularities in the spatial specific linkage science-technology, when controlling for the role of underlying variables, population and GDP. This is carried out both for "all fields" and for the sub-field electricity/ electronics/ instrumentation with a strong commitment in new technologies of information and communication.

The study is based on the 3-years average 1996-1998. Dates are publication years for scientific documents and publication years (for all patent applications) for European Patents.

#### B. Results 1 : the typology of regions

We know from prior studies (for example OST works, Barré et al., 1999 ; Zitt et al., 1999), that the picture of S&T European production at the regional level is marked by very strong concentration phenomena, and that this remains true when controlling for the variable population. We eventually grouped regions by couples of deciles, from class 1, of smallest regions often showing quasi-zero production in either activity, to class 5, of leading regions. Class 5 represents ca. 67% of publications, 58% of patents, 64% of large-applicants patents, 59% of not-home based large applicants' patents.

The representation of countries among classes is most uneven. The North-South polarity, as expected, structures the European landscape. In peripheral countries, and also Italy and France, a majority of regions is found in classes 1 through 3. France, clearly on the southern side from this point of view, shows a profile fairly similar to Italy. Mediterranean countries are still lagging: Spain has no region higher than 4 (and very few in 4), Ireland no region higher than 3, Portugal and Greece no region higher than 2.

In Northern and Nordic countries, classes 4 + 5 are the majority. Some similarities of profile are noted between Sweden, Finland, Netherlands, where class 5 captures half of regions, and Belgium and Germany, where it captures more than a third. Denmark and Austria stay in the middle, with a balanced profile between classes 4+5 and others.

Reading results the other way, the dominance of North among the top region class is conspicuous, with nearly 40% of class 5 provided by German regions, and nearly 20% by UK regions. France accounts only for 12%, to compare to relatively high scores of Netherlands (9%), Sweden (6%), Belgium (4%).

Looking at the national contents of categories, the well-known scientific vocation of the UK proves to be spatially distributed: one quarter of the regions are science-oriented, and one half when adding SE and ST. A minority is technology-oriented. The traditional contrast with Germany, a strongly technology-oriented nation, is also confirmed. Very few German regions are science-oriented (9%), while T and TE orientations each gather about one quarter of regions. Netherlands and Germany profiles are somewhat similar. France has also many TE (and also T) regions, but also some science-oriented ones (S: 13%).

Mediterranean countries go further than the UK in scientific orientation, with a nearly exclusive commitment: by European standards, they record neither T nor ST regions, and very few TE ones (none in Spain, Portugal, Greece, 9 in Italy). Italy has quite a high number of E-regions. This category without knowledge preference is mostly represented in Italy (64% of the class) and in Germany (6%), and residual elsewhere.

In addition, other dimensions of regional orientation, such as the balance between ranks in output and per capita output, the thematic diversity, and the correspondence between S&T specialities, were addressed. Diversity and S&T concordance reach a maximum for top classes.

### C. Results 2 : Science & Technology "Gross" Co-location

Beyond the evidence of an elite of wealthy regions, with balanced positions in S&T and hence theoretical advantages for science-technology transfers, the question arises of a more general relationship, in a large range of S&T size, between science and technology activities. This question was approached first by simple correlation studies ("gross" co-locations). A strong correlation will indicate that a balance exists between science and technology activities in a large scope of sizes. An implicit hypothesis (disputable) is that this balance of publications and patents resources will favour S&T transfers. Conversely, a low correlation will suggest that exceeding capacities either in science, or in technology, is the rule, a situation a priori not suitable for useful localised exchanges.

The science-technology correlation is moderate (0.59; without class 1: 0.32) for all Europe but clearly increases when controlling for S-T concordance (0.65; without class 1: 0.36). Using citations instead of publications slightly improves the figures. At the country level, a high-level of geographic coincidence between S and T (>0.8) is recorded in Sweden, (Greece, Finland). Denmark, France, Spain, Netherlands, the UK are in the middle (>0.55). Others show little coincidence, especially Germany with a very low figure (0.15).

The gross linkage of patents-Gdp is superior to patents-publication one, and resists the removal of class 1 (resp. 0.69; 0.58). It remains high in terms of per capita values (resp. 0.62; 0.60).

Naturally, concentration of population is a main substrate for concentrations of S&T. A look at correlation between population and other variables, shows that as expected the best linkage with population is obtained for GDP (0.94; without class 1: 0.92), then for publications (0.72; without class 1: 0.63), and last for patents (0.55; without class 1: 0.40). Partly neutralising the effect of population (by using per capita values or "densities") naturally tends to depress the level of linkage between other variables, for instance S and T. Publication (or citation) correlation with technology, in per capita values, are still much lower when the class 1 is removed. The next section reports a more systematic attempt to control for eco-demographic effects.

### D. Summary, conclusions and policy implications

The question of geographic coincidence of science-technology activities was addressed at the European level, using a breakdown into 450 regions. Geographic coincidence is a necessary condition for emergence of local spillovers or other S&T transfers.

A typological work was carried out, first by ranking regions on S&T output and per capita output, and distinguishing for convenience five groups, from the leaders to the very weak regions; then additional characteristics were depicted, first of all the general orientation towards science, technology, or economic

activities. The leading class concentrates almost two thirds of European S&T output - a confirmation of previous findings about the degree of concentration of science and technology in Europe – and a majority of leading regions displays a rather balanced activity between science and technology. The leading class also exhibits the best thematic concordance between science specialisation and technology specialisation, and a stronger representation of "large applicants" in patent production. As far as a geographic potential of localised spillovers / transfers is concerned, the regions belonging to the leading class can mobilise masses of knowledge in both areas, appropriate knowledge and academic knowledge, giving room for creative exchanges between science and technology.

Nevertheless, other classes cannot be neglected, and the question remains of the regularity of the coincidence between S&T over a wide range of regions "sizes". An insight in geographic co-location between science, technology and other variables such as GDP and population leads to the conclusion that technology-science correlation at the European level is quite noticeable, but much inferior to technology-GDP one. This is also true for most individual countries. The empirical linkage of S&T is interesting on its own, to assess the gross potential of exchanges between S&T currently available, but says nothing about the underlying factors, especially eco-demographic substrate, without talking of the mechanisms.

The next part of the study precisely aimed at isolating a possible specific science-technology connection, independently of other determinations. At what extent the spatial distribution of technology can be explained by science vs. economic substrate? Using multiple regressions, we found that, considering all regions together at the European level, the specific effect of science is at the limit of statistical significance. Gdp is a significantly better predictor of patents geographic distribution, in any form (all patents, large applicants' patents, not-home based patents...). Again, at the individual country level, this result is prevalent with few exceptions.

However, all these correlation studies were "global", taking all regions regardless of their specific vocation. Investigating more precisely the S and T relationship, we found that the collection of regions could be considered as a mix of two sets to be defined after the typology above, the "scientific" family exhibiting a science orientation (and possibly others), and conversely the "technological" family. The two families are overlapping in the area of leading regions, with balanced vocations, but tend to split elsewhere in a bimodal distribution (the quasi-zero regions should be excluded). When treating separately the two families, the effect of science becomes significant. For the science family, a predictive model will show a quite high elasticity of technological output as a function of the scientific output.

To conclude, Europe of science and technology displays a large variety of situations. Heterogeneity is the rule. The diversity of national innovation systems, and of infrastructures rooted in national economy history, has coined contrasting geographic patterns of science and technology location. The variety of regional orientations is also quite large. The typology we proposed allows a precise profiling of regions from this point of view. The "national effect" can be indirectly seen through the typology, with striking contrasts between countries as to their representation among classes of the main sequence, and categories of S, T, E orientations. Results are by and large consistent with OST-CEPREMAP's countries typologies.

The concentration of S&T outputs and resources in a minority of regions in Europe, probably due, in part, to virtuous circles of endogenous mechanisms, is a reality. In this "elite" of regions, powerful both in science

#### 1.4. Questioning the "internationalisation" of innovation systems (Work Package D)

##### 1.4.1. On the development paths of innovation systems (B. Amable, Y. Cadiou, P. Petit)

How then to assess this process of "internationalisation and technological change" and its effects on the complex architecture of SSIPs ?

First we take an overview of the architecture displayed by the various components of the SSIPs in the mid 1980s and early 1990s as elaborated in other works of the CDIS project. The evolution of sub systems of SSIPs which are less directly exposed to international influences, concerning labour market, education, scientific specialisation, R&D activities, technological specialisation, is appreciated on the basis of R.Barré, S.Paillard, Y.Cadiou, S.Petit [2000] (Work package B of the present report) and compared with previous work produced earlier by Amable, Barré and Boyer [1997].

The next step focuses on some specificities of the present phase of internationalisation. Following the central shift in the forms of competition at work in most countries, changes in international technology transfer and in finance transaction systems are considered as two prevailing and revealing aspects of the current specific evolutions.

The development of various forms of financing at early stages of innovation has been one of the example of specific institutional change and “organisational” innovations to consider. Similarly changes in the ways technology is transferred internationally. Sources on the various means to transfer knowledge or on the practices of MNEs to internationalised their R&D (making use of the work package C of the CDIS project) are analysed. The direct role that local agents, firms or institutions can have in shaping this technology transfer can also be checked referring to work package C of the project.

Finally we try to elaborate on the results recalled in the previous sections to assess perspectives of evolution of the SSIP under view.

An important issue addressed in this study concerns the characterisation of the EU.

EU countries are dispatched in five of the seven groups of the final typology found in WPB which conversely shows that to the exception of the UK, European countries are specifically distinct from non European countries such as the US, Canada, Australia and Japan which feature in distinct groups.

A key issue is whether this diversity can be turned into a positive factor of adaptation. Looking at sub systems which are more exposed to international pressure help in that respect to point at the possible synergies between EU innovation systems.

#### 1.4.2. Looking at technology transfers and at the forms of internationalisation

Transfers of technology that had been traditionally linked with the trade of equipment and the sales of patents obviously broadened their ways. With the development of intra trade flows (and the specific complementarities that this implies- detailed co-ordination of production ..and development of products as facilitated by the new relations between contractors via iso norms references) technological spill over could occur all along the line of trade flows. But on top of this extension, trade in services manifested important new means of transfer: from specialised business services to business travels, and also foreign direct investments (which, either in the form of green fields investment or acquisitions, imply some checking and transfer in technology of production and products).

We thus analysed data at the level of 14 sectors for inward and outward foreign direct investment, for imports and exports of goods and for the debits and credits in services (to which we added an analysis of the sectoral contributions to the trade balance) for 20 OECD countries. Detailed results of data analyses are given in annex of work package D of this CDIS project. The sectors which are structuring the readings of the various flows are thus respectively:

- for the inward and outward FDI: the presence of primary products, information technology equipment and business services (of which financial intermediation) is distinctive, which is rather expected.
- for the specialisation indexes in export and import trade flows, the presence of equipment goods, chemicals, refinery, metal industry, or “traditional” industries(textile, wood, paper) is explaining, again as expected from current analyses on crude trade specialisation. Intra trade was not explicitly considered here and we therefore registered a more traditional view on specialisation.
- for the specialisation indexes in credits and debits in service trade, the distinctive variables are spread across most items: travels, communications, financial services, transports, royalties and fees.

The reasons for the changes (if compared with the typology drawn from R.Barré, S.Paillard, Y.Cadiou, S.Petit [2000] are worth considering, due to the very different nature of the domains under view in each case.

The distance existing between the structural indicators we use and the fabric of institutions we want to reflect upon may well explain some changes in typology The structures of the economy are supposed to reflect the patterns of rules and practices induced by the fabric of institutions. But changes in the institutional background take time before becoming manifest in the structural indicators we used (see Barbier, Theret [2000] for examples.)

#### 1.4.3. Venture capital and innovation financing

The importance of finance in innovation is often associated with the growing importance of venture capital. Such statement is justified to the extent that venture capital as a specific means of financing and monitoring investment first gathers many of the specificities of both market-based and bank-based finance and second

has different expressions in different countries or SSIP, institutionally compatible with the existing sets of arrangements which characterise the SSIP.

Venture capital, involving screening and close monitoring, demands active governance. Therefore, it is more similar to an investment bank's type of involvement than an anonymous market for small shareholders. Venture capitalists do not usually possess the rights of a shareholder (no voting rights), they hold "convertible securities" rather than shares. Payments to venture capitalists are (partly) fixed and revisable according to the venture's successes or failures rather than decided by the management of the start-up.

One may expect some systems to be more prone to encourage venture capital than others may:

- systems where providers of finance are sophisticated enough (institutional investors) and large enough to have a diversified portfolio;
- market systems because venture capital-funded firms have to 'go public' after some time. If there is no liquid asset (shares) market, the whole success of the venture capital-funded start-up is jeopardised.
- Systems with patient actors (start-ups usually take time to become profitable businesses).
- But venture capitalists themselves are intermediaries, they need to find a source of finance which is willing to invest a part of its portfolio in long-term projects.

The origin of the funds to be invested is also a key characteristic of the venture. It may involve public or private fund, and in this last category more or less institutionalised and organised agents of different financial importance.

The very structure of an SSIP is telling about the forms that a specific venture capital scheme may take.

To describe the structure of venture capital we retain the indicators previously mentioned, i.e. the type of investor (corporate, private, banks, pensions funds, ...), the origin of the investor (almost half funds raised are from non domestic sources on average in Europe), the phase of the project (buy out represent half of the sums raised and start up 12%<sup>2</sup>), and the sector of investment (the high tech sector which includes communication, computer related, other electronics, bio-technology and medical/health related industries) amounts to 28% of the funds raised in 1998.

This data analysis concerns 12 European countries (EU 15 less Denmark, Portugal, Greece, Austria and Luxembourg, plus Switzerland and Norway.). The levels of new funds raised still differ largely between countries, it ranges from 8,959 millions ECU in the UK, 3,811 in France, 1,875 in Germany down to 222 in Switzerland and less than 100 millions ECU in most of the countries not included in the sample. This data analysis leads to the following typology of countries:

- In a first group we find The UK, Sweden and Finland,
- The second group associates France, Germany, the Netherlands, Italy and Spain, a group where the development of venture capital has been largely shouldered by the banks and insurance with more or less effective changes in the regulatory framework (as expected from public based systems of innovation).
- In a third group of countries Norway, Switzerland, Belgium and Ireland, e.g. countries with relatively small amounts of funds raised.

This typology seems much marked by the phase of development of venture capital in each country.

A similar analysis has been run on the means of technology transfers using the CIS survey It helped to portray how firms in a given countries are getting their information on innovation and to innovate.

Again to find that countries follow similar paths in setting up means of financing risky innovation process and in accessing information help to precise our assumptions on complementarities regarding institutional changes .

#### 1.4.4. Challenges on SSIs: towards a phase II

SSIPs are faced with a central institutional change in the present phase of economic development centred around the forms of competition, influencing the ways in which economic transactions are informed and

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<sup>2</sup> Even if seed and start up projects represent nearly a third of the total number of projects.

conducted. Such situation is common to all developed economies which in itself is an important feature of the contemporary transformation (which confirms its international nature).

It would however be misleading to conclude that nothing changes in SSIPs. The analysis of economic performance in connection to institutional specificity must avoid two mistakes: the first one is to consider that all countries are subject to world-wide trends that leave no room for variety among developed economies, and to apply a 'one size fits all' analysis to modern capitalist economies. There are various instances of this mistake, the most common takes the form of a recommendation to adopt the institutional features characteristic of the country which enjoys the best macroeconomic performance at the time of the recommendation (France in the 1960s, Germany in the 1970s, Japan in the late 1980s, the US in the late 1990s,...). Another variant is to isolate a key mechanism of evolution of modern capitalist economies affecting all countries, for instance financial liberalisation. The next step is to conclude from the forms that this evolution takes in one country (usually the country which has the best macroeconomic performance at the time) that all modern economies will (or should, depending on how normative one wants to be) take the same path, regardless of the structure of the national economies concerned. This is in a way an evolutionary argument. There is a new general evolution principle for developed economies to which countries should adapt or die.

The second mistake is to consider that variety is so significant that the evolutions that affect all economies at the same time are of secondary importance compared to the structural inertia that characterises the various types of capitalism. Technological revolutions may come and go, the hierarchy of institutional forms may be altered, internationalisation may take different forms, Germany will always be Germany, etc.

The general change in the forms of competition has pressed for a more rapid flow of innovations and therefore for a more dynamic, risk taking behaviour regarding the financing of innovations. This common drive for a "venture capital" was given very different answers according to the type of financial system and to the other characteristics of the SSIP. Analysing the diversity and the rapidity of these answers gives a good illustration of the dynamics of institutional change. Our analysis stressed the dominant positions of some early which reacted promptly to the need, it shows how some traditional banking has been able to adapt its structures or how some public based system also showed adaptive capability.

The role of MNEs for instance can be seen as evolving during the present phase of internationalisation. Regarding both finance and R&D they seem to be less attached to their home countries. In such second phase MNEs would be important actors in setting some new forms of international organisations. The distinction between host and home countries in that respect would be significantly modified.

As the evidence presented in the previous sections show, some SSIP have been more robust than others. Considering the evolutions concerned, it is not surprising that the market-based SSIP has maintained its stability, accentuating its characteristics. But the current vogue of market mechanisms should not conceal the fact that among the countries belonging to this SSIP, only the US enjoy a clearly outstanding macroeconomic performance. In other words, and this is not surprising, there is no univocal link between a certain institutional architecture and certain macroeconomic performance.

The meso-corporatist SSIP has kept most of its specificities, the only change with respect to the previous decade concerning the macroeconomic evolution. The SSIP which is characteristic of South-East Asia has experienced its worst decade since the end of the second world war. Countries specialised in mass-production ranging from average (Korea) to very high (Japan) quality have found it difficult to adapt not so much to a new type of product innovation (less incremental) than to the new phase of financial liberalisation. This last factor threatened the whole structure which had supported their tremendous economic success for several decades.

Changes in the pattern of internationalisation has had more influence on the other two SSIP. Finland and Sweden, the more technology-intensive countries of the social-democratic SSIP, seem to follow separate paths from Norway and Denmark. Norway seems to some extent closer to the market-based SSIP whereas Denmark has some common characteristics with the public SSIP.

This last SSIP appears once again the less homogeneous and the less stable of all systems. Both internationalisation and financial liberalisation have subjected the countries of this system to divergent

evolutions. Italy shares important common characteristics with the Mediterranean countries, as far as foreign trade, technology and specialisation are concerned. On the other hand, Germany and the Netherlands are closer to some countries of the Social-democratic SSIP than France or Belgium. These similarities or dissimilarities already existed at the time of the analysis performed in Amable et al. [1997], but it appears that no convergence has been underway since.

Questions concerning Europe are then centred on the heterogeneity of countries in the EU. This heterogeneity is not a problem *per se*, but with respect to a common European technology and industrial policy. Considering the various SSIP European countries belong to, it is obvious that European policies regarding competition, deregulation, privatisation, etc. are going to have different consequences on the dynamics of countries according to whether they are part of the market-based SSIP, the social-democratic SSIP or the public SSIP. As the analysis already shows, the latter system appears the more fragile of all, all the more that the countries belonging to this system have mostly had mediocre economic performance during the 1990s. One may argue that subject to policies that seem to steer countries toward an extension of market-based mechanisms, the fragility of the public SSIP will imply a radical change for countries belonging to this group. Consequences for innovation and technology may be far-ranging since the specific form of innovation favoured by this SSIP (programs, rather radical technological advances,...) may be endangered.

Another aspect concerns the regional dimension of technology. The results presented above do not indicate a radical autonomy of the regions from their home countries in their economic and technological development. The 'technological geography' of regions is of course more complex than that of countries, but what comes out the analysis does not contradict the prevalence of 'macro', national-level institutions over more local dynamics. This does not mean that regions have no development autonomy, but that this development takes place under the influence of the macro-level institutions that define the SSIP. Therefore, the effectiveness of regional policy will crucially depend on the institutional features of the countries the regions belong to.

overall conclusions – innovation policies for the social systems of innovation and production in the context of the European Research Area dynamics

On innovation policies

Policies have in common to support successful adjustments of SSIPs. From there, policies can be placed in two main categories:

- the “direct” innovation policies which intend to act on the working of the innovation systems themselves by targeting some specific aspects such as R&D orientation, educational attainments, labour market “flexibility”, or the opening of international relations or finance. Measures in this category are looked at separately. One can distinguish in this category active and passive innovation policies (somehow as it is done regarding labour market policies) depending on whether policies aim to improve the innovation resources for the future or whether they intend to favour either some catching up or scrapping of units of production lagging behind.
- the comprehensive policy actions which try to change the broad context determining the SSIP, taking into account the interdependencies between the above-mentioned aspects, such as the labour market, the finance systems and the international relations as well as R&D and education. This approach focuses on the linkages that may exist between these various aspects, in order to strengthen the policy effects and reduce counter effects.

Both types of policies are complementary. The many recommendations one can design in a direct innovation policy perspective should then be cross-checked looking at the linkages that define the comprehensive SSIP. Taking advantage of institutional complementarities not only broadens the scope of action but also can limit the counter effects that may hinder actions suggested by direct innovations policies. Direct innovation policies conversely help to specify the micro economic rationale for policy actions.

Since the above combination of direct and comprehensive policy actions takes a national perspective, then, the question of the interdependencies between the nations must be raised. This interdependency argument is of course all the more important when countries are in a Union empowered with a specific room of manoeuvre for policy intervention. This argument raises the issue of international co-operation, both at European levels but also at a global level, as it has been clear that most of the challenges of internationalisation (and in particular the organisational choices of Multinational firms). This challenge concerns at least the US and Japan along with the European countries as well as the policy actions of many international bodies starting with WTO. Issues at this level are specific. Again to consider systematically how measures may imply some contradictions at a regional or international level helps check and validate the realism of the recommendations.

For this reason we shall add to the two previous categories of policy a third level of policy interventions, related to the international level, which we shall call strategic innovation policies. The types of issues and interventions concerned by this level will help to assess the kinds of measures required to develop a European research Area. These questions will be addressed at the end of this section.

To speak in more concrete terms, the policy issues will first be presented by fields within two ranges of issues, concerning respectively the development and transfer of knowledge, and that of finance.

Secondly, within each range we shall consider issues which are related to the transformation of key-components of the SSIP, namely the wage-labour nexus and the organisation of markets. This will help to address issues related to the coherence and relevance of the direct innovation policies.

Thirdly, since the two above-mentioned aspects are directly affected by the process of internationalisation, we will add a strategic perspective which takes into account some of the international aspects.

Table 4 - Policy issues and their contexts

<b>Areas of policy</b>	<b>Forms of competition</b>	<b>Wage labour nexus</b>	<b>System level</b>
<b>Range of issues</b>			
<b>Development and transfer of knowledge</b>	R&D policies Spatial planning Agglomeration effects Economic geography	Education Wage structure Mobility Leisure policies Consumer policies	Comprehensive approach on knowledge related issues
<b>Development and transfer of finance</b>	Agglomeration effects Development of venture capital and specialised financing	Pension funds Saving Wage structure Mobility	Comprehensive approach on finance related issues
<b>International level</b>	Strategic approach In terms of Competition forms	Strategic approach In terms of wage labour nexus	

On strategic policies looking at international co-operation and competition

Our studies in the CDIS project often stressed the lack of international co-operation in issues such as the localisation of MNEs, the opening of financial markets and venture networks, the management of intellectual property rights, the development of top quality science centres or of basic research schemes.

A key issue in that respect is whether regional agreements and developments can fill this need. This raises the question of the European Union and what can be developed at its level.

The answer is somewhat balanced. Obviously, many issues can be solved at this regional level (when they cannot be addressed for some of them at national level, see the IPR issue). Still this regional level is also deeply interlocked with a global level where actors, mainly MNEs, have been developing their strategy.

Still the role of Europe can be usefully developed in many directions to facilitate the adjustment of member countries as well as to give the whole Union a substantive role in the shaping of arrangements at the global level.

The role of EU integration in the dynamics of the EU SSIP types is definitively helpful – sometimes crucial - for member states to catch up with world-wide common trends (knowledge society) and to take advantage of some EU-specific aspects (as given by wage labour nexus paying on average more attention to social cohesion issues or deeper commitments of the citizens to preserve and improve the quality of life in European societies).

The question though is whether such policy lines should be developed at the level of Europe as a whole or at the levels of sub groups of European countries which are closer in how they address the welfare issues. The development of an Euro group, even if it gathers a majority of member states, has definitively paved the way for such path of “à la carte” developments.

Such European research area should be in coherence with world wide trends in terms of the advent of a knowledge society, which means an increase in the volume of a number of activities (S&T, RD, higher education ...)

Secondly, this European research area should take into account and build on the features of the EU-Area SSIP model: such features are shared by EU member states, but in forms which are specific to them. They constitute both constraints and opportunities which are at the root of EU specific comparative advantages in world competition. The socially protective labour regulations can represent advantages in terms of attractiveness and know-how accumulation both in the public and private research and innovation sectors ; income equality is the basis for large demand of high quality goods and services, as well as a potential for skilled labour. We suggest the present challenge is largely to characterise better what could be considered as a

European social system of innovation and production and its implications for the European research area in terms of building comparative advantages out of those specificities (at world level), which we share (at EU level).

Yet the risks of divergence that the diversity of European SSIPs contain should not be underestimated and appropriate resources developed to avoid the development of centrifugal forces. The Union in that respect may favour the development of community based institutional schemes in most cases where innovation policies are aiming at some catching up or scratching (what we called the passive innovation policies) in order to avoid a broadening of the gap between countries more inclined to rely on market mechanisms and countries more inclined to rely on national schemes to promote the innovative capability of their economy. In that respect policies aimed directly at the quality of life and welfare of European citizens would be clearly both the best political support and the more effective grounding of economic growth at a time when the decisive step for a durable growth concerns the reconstruction of an “updated and upgraded” effective demand.

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## 2. Background and objectives of the project (including reorientations)

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This research focuses on the taxonomy, diversity and recent evolution of the systems of innovation and aims to derive new principles and tools in order to govern science and technology policy in the era of European integration and larger interdependence at the world level.

Three main avenues are explored.

First of all, the renewed interest for endogenous technical change or neo-schumpeterian analyses has put a strong emphasis upon the role of innovation...but they do not deal explicitly with the network of institutions (organisation of science, incentive for R&D expenditures, industrial relations, tax and credit systems, forms of competition,...) which shape the direction of innovation and the speed of diffusion of technological and organisational advances. This project builds upon the emerging literature on national systems of innovation, in order to propose a theoretically grounded and empirically relevant analysis of the various contemporary configurations. Statistical econometric and institutional analysis will simultaneously be mobilised in order to diagnose the configurations prevailing among OECD countries and some Asian NIC's. This could be a very useful tool for policy makers.

Second, a previous research hints that the 90's might well be a turning point in the competition among the four major social systems of innovation which used to coexist during the 80's. This proposal digs a neglected question: why and how do systems of innovation evolve? By a close investigation of the internationalisation strategy of the large corporations and a careful analysis of the endogenous transformation of local systems of innovation during the process of European integration, the project intends to enlighten the trade-off between diversity and dynamic efficiency in a more interdependent world. The global structural competitiveness of European Union as a whole will be analysed and a special attention will be given at the recent transformation of Japan and its region of East Asia and its impact upon European specialisation.

Last but not least, this framework has definite consequences for the orientation of S&T and other policies. During the Golden Age, the hypothesis of a catching up with respect to the technological frontier of American mass production was implying that policies should be nearly the same all over the world. Nowadays, the recognition of local idiosyncrasy, sectoral specificity and path dependency of industrial specialisation, calls for a more balanced approach. Given the diversity of local systems of innovation, the same policy may deliver opposite results. Conversely, to warrant an equal dynamism of innovation, different policy objectives and tools have to be developed for each configuration. Along this central message, this project aims to provide new guidelines for policy makers at the local, national or European level.

### 2.1. Objectives

#### 2.1.1. Systems of innovation are important: the current state of the art

The past decade has witnessed a large number of studies on the relationships between technology and the economy. The slow-down in productivity growth rates in industrialised countries, the emergence of newly industrialised countries, the relatively poor performances of Europe in terms of growth and employment relatively to Japan and the United States, a context of fast innovation in some industrial sectors... all these factors have raised new concerns for the long term sources of growth and competitiveness.

The idea that innovation is a social phenomenon rather than the isolated act of an individual entrepreneur has been developed into a broad theory that states that countries are characterised by their "systems of innovation". Scientific discovery, innovation, diffusion of technical progress, skill upgrading, education, firms' internal mode of organisation or investment in equipment contribute together to economic growth. Each of these elements is influenced by factors that are partly specific to a certain area (the scientific community, the education system, the banking system,...) and partly interacts with other areas of society or the economy. The country-specific pattern of interactions between all the areas that contribute to technical change and economic growth has been referred to as the national system of innovation by many authors.

To use a well known expression, institutions matter, particularly by the pattern of complementarity that national institutional forms exhibit. The limits of market based allocation in presence of external effects

provide a minimal theoretical (microeconomic) basis for the importance of institutions. Technology choice when there are increasing returns to adoption is known to lead to lock-in phenomena, potentially with sub-efficient technologies, knowledge accumulation involves large external effects... All this points to the importance of rules and regulations concerning intellectual property, patterns of Public intervention in science and technology or education and training. Technical change is a systemic phenomenon that brings together determinants that go beyond the limits of science and technology *stricto sensu*.

This feature has been pointed out and investigated by many scholars (Christopher Freeman [1987], Bengkt Ake Lundvall [1992], Richard Nelson [1993]) who designed the concept of national system of innovation. More recently, Bruno Amable, Rémi Barré and Robert Boyer [1997] have proposed the notion of social systems of innovation and production as a set of routines, procedure and pattern of interaction between institutional forms that influence innovation and diffusion behaviour at the micro and macro level. In the same vein Winfried Ruigrok and Rob van Tulder [1995] have pointed at the importance of so called 'meso-institutions' in characterising differences between various business systems around the world neither pure market nor centralised planning constitute efficient forms of economic allocation, a variety of institutional configurations governing technical change may exist, produced by history in a process that owes more to trial and error than to perfect rationality. This particular type of path dependence questions the relevance of the idea that all countries converge towards the same technological (and institutional) model and should therefore enjoy the same growth rates in the long run.

The empirical analysis performed in Amable, Barré and Boyer [1997] concerns about 200 parameters for 12 developed countries. The objective was to isolate the different contributions of various components of a social system of innovation (the science and technology system, the industrial sector, the financial system, the training and education system,...) with the help of data analysis. The following conclusions can be drawn from the analyses performed.

Concerning macroeconomic performance, one can, *grosso modo* and for the moment, oppose two models: industrial restructuring and a minimum of solidarity with a high and slowly rising unemployment on one side, lags to adaptation to new production methods and rising inequality but a moderate level of unemployment on the other side. The first pattern is that of (continental) European countries, the other one represents Anglo-Saxon countries.

In the field of science and technology, there appears to be a complementarity between scientific specialisation, patenting specialisation and the nature of constraints and opportunities that characterise a given national territory. The US and the UK have a strong specialisation in aerospace and pharmacy, Japan and Germany couple specialisation in engineering sciences and mechanical industries, Finland, Norway, Australia, Canada and Sweden have built their innovation systems on applied biology and natural resources intensive sectors.

Regarding the systems of innovation and production, akin to the *modes de régulation*<sup>3</sup>, the classification coming out of the data analysis distinguishes four groups of countries. Japan stands apart from the other countries, associating a strong specialisation in electronics and equipment goods, a high R&D intensity, a well trained labour force and a bank-based financial system. Scandinavian countries are characterised by a strong internationalisation of the research activity, a technological specialisation directed towards resources intensive activities, high education expenditures and a not too sophisticated financial system. Continental European countries belong to a third type. They are characterised by a scientific specialisation in physics and chemicals, a certain lag in innovation capacity. Anglo-Saxon countries are specialised in biology, aerospace and pharmacy, are lagging with respect to the adaptation to new principles of organisation, favour external flexibility in the labour market and have a sophisticated financial system relying mostly on markets.

Thus, one observes empirically strong complementarity between the mode of organisation of firms, the organisation of the scientific sector, the pattern of industrial research, the institutions governing intellectual property, industrial specialisation, the type of labour markets, the type of financial systems,... The grouping of countries according to four types put in a broader perspectives the results gathered when studying strictly national systems of innovation. Two major consequences can be drawn. First, each different type has its own dynamics, partly due to the internal evolution of the relevant territory, consequence of the strategies

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<sup>3</sup> See Boyer [1986], Boyer et Saillard [1995].

implemented within the considered configuration, and partly due to the competition between countries. Second, the same policy measures concerning science, technology, labour markets, financial deregulation ... will have different effects in each type, because the nature of interaction between the different subsystems considered is fundamentally different for each of the four types.

#### 2.1.2. Causes and consequences of contemporary changes in national systems of innovation: the core issue of this project

Given the current state of European integration and internationalisation, systems of innovation are evolving and the major aim of the project is to assess the impact of these structural changes upon the diversity and global performances of these coexisting innovations system.

On one side, the members of the project have developed alternative approaches about the regional, national and international determinants of innovation: it is specially interesting to elaborate a new analysis, which would check the validity as well as the stability of such conceptual scheme as the four social systems of innovation model previously diagnosed

On the other side, statistical indexes are now available in order to run new tests, operating upon of more detailed and up-dated data on science, technology, economic and financial institutions. This research builds upon the new statistics generated by the first TSER co-ordinated by OST, as well as the expertise of the participants on the role of multinationals in the dynamics of innovation and competitiveness. More precisely, four major issues will be investigated.

1. Do we observe a deepening of scientific, technological and/or economic complementarity between the member States belonging to European Union?
2. How far does internationalisation influence the viability of social systems of innovation which used to be largely nationally or regionally based? What is the role of multinationals in this process of diffusion of know-how?
3. How has the competitive edge of EU evolved since the early 90's, by comparison with North-America, Japan and Asian countries?
4. What are the consequences of the expected results for the design of local, national, European policies concerning science and technology? What is the role of networks in the spread of innovation along a supply chain? What new instruments are required to preserve diversity, social cohesion and economic performances?

#### 2.2. Work content - Methodology

The main issue to be investigated concerns the viability of social systems of innovation and their transformations under the process of European integration and more international dependence. The research will combine quite diverse but complementary approaches, methods and data or fields of investigation.

The work content of this project can be described in a sequence of four questions with the respective work packages proposed to answer them.

The sequence has a logic which runs as follows.

The first question goes back to the central notion of this study: what a system of innovation is. It is addressed to a broad community of specialists and asks: what a NSI does, which institutions it involves, at what level it operates and finally how it performs (Work Package A).

The second question bears on the diversity of national systems observed in Europe and how they fare compare to other very different systems such as the one of Japan (Work Package B).

The third question focuses on the working of NSI at specific levels: the regions and the multinational firms, looking for more information and scope on the conflicting issues that may arise at these levels (Work Package C).

The fourth question then addresses the core issue: what is the impact of economic integration and internationalisation on national systems of innovations (Work Package D).

##### 2.2.1. Conceptual analysis of social systems of innovation and production: what is a system of innovation? (Work Package A)

Some theoretical and methodological clarifications have been made on the issues raised by the notion of a national system of innovation in order to appreciate a) the relevance of such concept as the one of social system of innovation, b) the range of institutions concerned, c) the basic dynamic of the system under the pressure of internal as well as external changes.

Of special interest are the questions relating to the chains of causes and consequences involved in such systems of innovation. There is a risk that the notion of systems of innovation simply collects sets of institutions which do not play at all the same role in stimulating innovation in the production processes. Firms have many ways to innovate which do not directly rely on the set of institutions retained as relevant. Critics of the notion of NSI should help a) to rank institutions in accordance to their role, b) to relativate the conditions under which institutions (such as universities) are effectively operating and c) to see how firms can overcome some of the limits of their national systems.

It will among other things hint at the possibilities for national systems to compete when firms can organise their production processes at world-wide levels.

Judging the performance of NSIs is also a challenge that could be clarified in this first debate and critical survey of recent works on the topic. The assumption is to often made that the performance of an NSI can be read through the achievement of one country in terms of competitiveness. Various alternative patterns of efficiency should be checked. It may well be the case that the performances of such SNIs remain greatly dependent on the external conditions given by world markets and the characteristics of best practice technologies. No system can pretend to be adapted to all « weather » conditions. The performance of systems of innovations in such perspective would be dependant upon external conditions.

It may also be the case that NSIs have a life cycle of their own whereby their effects could be optimal at some stage (of their expansion for instance) and erode at other stages (when institutions are ageing or have stopped their expansion or receded).

#### 2.2.2. Structure and stability of systems of innovation in 22 countries (Work Package B)

There is a need for the project to identify in more precise manner, eg in accordance with its overall acceptance of the notion of NSI, the diversity of systems existing in Europe.

questions addressed and aims

The aim of this Work package is to explore quantitatively the diversity of innovation systems in Europe using a variety of sources and to assess their transformations during the two last decades.

The questions addressed are the following:

- are there different configurations ? if yes how can they be characterised ?
- what is the dynamics of these configurations ? are they stable over time ? do they converge or diverge ?
- is the dynamics different for different sub-systems ?
- is there a specific pattern for EU countries ? what could that mean for the European Research Area ?

We want to assess the diversity of national innovation systems observed in Europe and what is their dynamics. We aim here at an overall perspective of the notion of SI, at characterising the diversity of systems existing in Europe and elsewhere, in order to give broad views of the SI of some European countries.

#### **Operational objective: to update and extend a taxonomy for national systems of innovation and characterise their dynamics**

The operational objectives of this work package are :

1. to survey a large number of possible SSI parameters and select them in terms of the availability and quality of data,
2. to establish a typology of Social Systems of Innovation (SSI) and characterise different SSI types, thus revisiting the previous taxonomy of social systems of innovation established by Boyer, Barré, Amable [1997],
3. to provide a dynamic perspective for these Social Systems of Innovation over the period 1986 - 96,
4. to deepen the analysis by explaining the overall structure, typology and dynamics by the role of various sub-systems.

The fact that the Japanese economy is now one of the top leading economies of the world is forcing the Japanese system of innovation to adjust to face its new dominant position. Japan has been devoted a great deal of interest by Europe in the past.

Research within the fields of contractual relations between firms and internal employment relations within firms. has offered a basis for assessing how the Japanese national system of innovation has been structured.

However, the time should be ripe for a re-assessment of conditions in Japan. On the national level, issues of both external and internal ramifications are currently being discussed. A prevailing theme is the question of how the Japanese economy in the future should relate to its neighbours in Asia as well as to Europe and the USA. A Sub-Project on Japanese policy initiatives at the national and corporate levels will contribute to the analysis of some of the challenges arising for Europe from developments elsewhere by way of placing particular attention on selected aspects of the evolution of the Japanese economy. In concrete terms this meant to gain increased understanding of (a) policy initiatives at the national and corporate levels and (b) R&D/innovation activities as they are undertaken by selected Japanese firms.

### 2.2.3. Specific crossed perspectives on systems of innovations: the regional and multinational firm levels (Work Package C)

To improve our knowledge on the very roots of national systems of innovation and on their working it is interesting to focus on such important dimensions, not so much referred to simultaneously, as the regional and the multinational firm perspectives. In both cases specific actors and strategies are at play, which can reinforce or on the contrary weaken the national characteristics of the system. It is an assumption of the project that some points made at these levels can hint at some of the contradictions at work in national systems ; which would account for the frequency and the intensity of internal pressure and constraints. All of which are key factors to understand the evolution of the systems, whether it is submitted to external pressure or not.

#### Looking at regional levels.

The advances in the building of sophisticated data banks will be used to diagnose the existence of contrasted social systems of innovation. The previously proposed taxonomy will be sharpened and extended with the new indexes. Data analysis and econometric tests will be used in order to check what are the relevant variables which explain either convergence or divergence of specialisation according to various domains (science, technology, economic structure...). By comparison with a cross section analysis made for the early 90's, it is expected to check the direction of evolution of the social systems of innovation

The empirical analysis concerns about 20 countries from Europe, each one being characterised by parameters related to (a) scientific activities and specialisation, (b) technological and industrial research and innovation, (c) economic and industrial structure.

The objective is to get a more systematic view of the various types of systems of innovation and an understanding of the relationship between innovation systems and performance, through various data analysis.

#### Looking at the levels of multinational firms.

It seems that various innovation systems trigger different kinds of internationalisation strategies of firms originating in these countries.

This is precisely the point under investigation in the second part of this operation.

All available statistical information concerning the pattern of localisation of research and development will be used to deliver estimations about the share of large multinationals in innovation activities. Do their strategies erode the previous legacy of localised social systems of innovation or quite on the contrary do they reinforce already existing spill-over effects and specialisation?

These issues can be investigated by using two complementary data sets.

On one side, a first empirical analysis consists in identifying, for Europe at the regional level (NUTS 2 or NUTS 3), the relationships between the research activities characteristics of each region and those of the research activities of the foreign multinationals subsidiaries located in this region ; such relationships will be assessed both in terms of the volume of the activities concerned and of their scientific - technical orientation.

On the other side, a second analysis starts from the international strategy of the large firms. This part of the research will further dwell on a database that is developed parallel at the Erasmus University in which the

internationalisation strategies (in sales, employment and production) of the 200 biggest multinationals in the world are systematically researched for the 1990-1998 period. It is already observed that there is a clear link between various social systems of innovation and particular internationalisation strategies (cf. Ruigrok and van Tulder, 1995). At the same time there is a clear strategic interaction between the various internationalisation strategies. Firms do not develop their internationalisation in isolation, but do that in an action-reaction pattern. Rather than speak of different internationalisation strategies, it is therefore often more adequate to talk about "rival" internationalisation strategies.

The research efforts are aimed at complementing the information in the database with material on research and development policies of the 200 biggest multinationals. Since many of these multinationals make up a sizeable part of the private R&D infrastructure in many countries, the information on these "core firms" can be considered representative. This part of the research project focuses in particular on the effects of patterns of internationalisation on the 'home' end of the social system of innovation.

These data will help to analyse how the strategies of the firms and national or regional governments interact. Do multinationals exploit locally manufactured competence or conversely do regions compete in order to attract a fraction of RD and related innovations which are now operating within large trans-national firms? The aim of this sub-project is to deliver a new and more satisfactory framework, dealing with these two conflicting forces of localisation and internationalisation.

From the set of core firms as covered in the database, a sample of around twenty European, American and Japanese multinational firms will be taken. In this sample of firms it will be considered in more detail how the interaction with firms down the supply chain, as well as with the local knowledge infrastructure (universities, other private laboratories) is shaped. Information on the European pre-competitive collaboration programmes (like Esprit, Brite-Euram) as well as other types of international strategic alliances will be considered to get a good overview of the various strategies in R&D chosen by multinational enterprises in Europe. Questionnaires will be developed to check for the impact of "location tournaments" or "policy competition" on the actual decision of firms to locate what parts of their R&D process in regions beyond their original social system of innovation.

#### 2.2.4. The impact of economic integration and internationalisation (Work Package D)

Finally, all the previous investigations should converge towards a common aim, i.e. explore the effects of Europe integration and over all internationalisation on the various systems of innovations.

The issue could be addressed in four steps.

In the first place tries to identify the recent effects on national systems of the various stages of Europe integration. Did it affect the geography of NSI, eg the similarities or differences between the subset of SNI that we consider? Are these effects more or less identical or convergent at regional levels or at the level of the strategies of multinational firms?. The Work packages B and C help to feed this comparative analysis.

The second step tries to assess whether or not in the 90s a shift occurred in the relative performance of these systems. Changes in the determinants of competitiveness as well as the development of world wide markets and an extended internationalisation of production processes could well have eroded the links of NSIs with performance. The reason for changes in achievements may well be linked either to internal factors (erosion and ageing of national systems) or to external factors (easier access to international markets and factors), including to changes in the overall economic context.

To try to sort out these outcomes is a preliminary step to the assessment attempted at the third step to appreciate how complementary appear the European systems of innovations at the end of the 90's, once the single act is nearly completed and as the monetary union is just about to start. The challenge is to characterise what could be considered, at this stage, as a European (social) system of innovation.

The fourth and last step directly attempts to assess the efficiency of this would-be European social system of innovation by looking at the competitiveness of Europe vis-à-vis the United States and Japan (or more exactly of Europe within the Triad).

A comparative growth approach, including a thorough evaluation of previous work in this area (the World Bank study and the ensuing debate) and new empirical work based on the most recent and desegregated data

sets will be used for the purpose of identifying the role played by leading/strategic sectors in the new relevant policies undertaken in Asia, America and Europe to sustain their competitiveness.

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### 3. Scientific description of the project results and methodology

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#### 3.1. Conceptual analysis of social systems of innovation and production: what is a system of innovation? (Work Package A)

##### 3.1.1. CEPREMAP results and methodology (Bruno Amable, Pascal Petit)

Research on innovation and growth in the past decade has emphasised the role of firms' innovative investment in technological change, whereas a more traditional approach to technology tended to stress the role of public institutions in the creation of freely accessible scientific and technical knowledge. This focus on innovative activity as an outcome of purposeful action undertaken by profit-seeking firms should not conceal the fact that specific efforts made by private actors take place within a certain institutional context. This general statement certainly applies to all economic decisions, but has a particular importance in the field of innovation and technology, first because of the involvement of the public sector in such upstream domains as education and research, but more fundamentally because of the characteristics of the innovative activity or the accumulation of knowledge. They involve a great deal of external effects and uncertainty whose influence on the economic performance is mediated by the network of institutions which positively or negatively affect the decisions of economic agents and as a consequence economic performance of firms and nations.

A strand of literature has paid special attention to the role of institutions influencing the creation of technology, proposing a theory of innovation which did not consider a linear model where the origins of technology creation would be found in firms' laboratories, but a more interactive model where the dynamics of innovation is both demand-pulled and supply-pushed, and where positive and negative feedbacks are explicitly considered. The nature of the feedback effects shape the technological trajectories and ultimately the performance of the economies considered. In this perspective, the innovation process of firms of a certain country should be seen within a system which possesses strong national characteristics.

The notion of 'national systems of innovation' (NSI) has spread beyond the boundaries of the academic world and influenced policy makers in their definition of interventions in the technology policy realm. The main message of the NSI approach is that the institutional context not only influences but also shapes the innovation process and plays a genuine systemic role in technology creation. This has far-reaching implications for the definition and implementation of innovation policy.

The NSI approach and more generally the notion of system itself raise in itself two questions, which the approach adopted in our research aims to address:

- Where are the boundaries of the system(s) in terms of institutions and geographical space?
- 
- What is the pattern of evolution of these systems and how stable are they over time?

The former point refers to the possible existence of sub-systems at some sector or regional level. It also questioned the role played by large firms and localised districts of small and medium-sized firms in the innovation process. Even the thread of the fabric of institutions selected in NSI approaches can be qualified, as institutions may play various roles in this fabric. The whole investigation leads to static comparisons of various systems based on a theory of interactions and complementarities between institutions and forms of organisation that influence directly or indirectly the creation of technology. The advantage of the approach adopted in our research is that beyond the specificities of each country, one may distinguish 'types' of innovation and production systems and have a more structured view of growth patterns.

The latter point questions the consistency of the notion of innovation systems over time. Does the system evolve as such with the economy as a whole or does it change in its essence in recomposing its boundaries? It may seem paradoxical that the notion of NSI was developed at a time when countries appeared to be become more structurally internationalised. In order to overcome this obstacle, one must see innovation and production systems not as pre-existing structures but rather as historically contingent configurations of institutions, forms of organisation, accumulated capital and competencies. One cannot dismiss the idea that they can evolve towards some new configuration with different boundaries and structure or even simply vanish.

Because innovation and production systems are bound to evolve with the forms of internationalisation of the economies, it is likely that national systems will turn into a new set of interconnected open systems.

### **The limits of the notion of 'national systems of innovation'**

The concept of innovation system (IS) has been the focus of many studies and some papers have already surveyed the field. There are two broad levels of analysis:

- The most basic revolves around a firm and its local environment. Innovation involves complex interactions between a firm, its network of suppliers and customers, and sustained interactions between users and producers of technology. Inter-firm linkages are more important than arms-length market relationships. Institutions affecting the pattern of interactions between economic units are to a large extent national and hence all interactions in the same country will have common determinants.
- The wider context is fairly vague: it refers to broader contexts conditioning innovative activities such as cultural aspects, social customs, national traditions and regulations...

Those arguing that the influence of national-specific institutions is limited and that the influence of regional or even sectoral systems of innovation is more important oppose the views expressed at both levels of analysis. Supporters of the regional or sectoral IS view tend to downplay the importance of macro-level institutions and inter-sectoral determinants and to emphasise more localised channels of interactions. The sector pre-eminence for instance can be seen as a consequence of the pre-eminence of the demands of technology in shaping the firms' mode of organisation and pattern of inter-firm relationships. Technology itself would then exert higher-order influences on economic actors than any other determinant, in particular the network of national institutions affecting the innovative activity. More generally, strictly technological determinants tend to dominate other possible influences: local knowledge externalities flowing within regions are considered the main structuring factor for regional IS, or the sector's technology is considered as the most important factor for the pattern of firms' interrelations.

Influences at the wider level explain why one may speak of a national system of innovation and not just local systems centred on particular firms or networks. The pattern of relationship is not just specific to a particular network, but to all economic units belonging to a given 'culture'. But the macro-level is not only a matter of national culture, whatever this concept may be. The pattern of co-ordination of economic units involves macro-level institutions, which somehow gives a macro-level coherence to more regional or sectoral patterns of interaction.

The next important idea of the NIS approaches, and the prime reason for the comparative study of IS, is that national structural differences are taken to explain diversity in growth performance of the different countries. An implication of the IS approach is that technological differences coming from differences in national IS can be observed with the pattern of technological specialisation. This is why the bulk of empirical work done on IS has paid a great deal of attention to the pattern of industrial specialisation in relation to the pattern of scientific or technological specialisation.

To sum up, one may follow Smith [1998] and give three basic conceptual underpinnings of the IS approach:

- Economic behaviour rests on institutional foundations. The consequence is that different modes of institutional set-up lead to differences in economic behaviour and performance.
- Competitive advantage results from variety and specialisation, it has path-dependence-inducing effects. Successful specialisation are self-replicating, with system creation as an outcome.
- Interactive learning generates technological knowledge. This gives different knowledge bases among different types of economic agents.

The first one is an important element which puts the whole range of IS approaches in line with other institutions-based approaches in economics. The second point stresses the focus of IS approaches on external competitiveness and activity specialisation in their assessments of national trajectories. The third point is more evolutionary in spirit. It may also be seen as hinting to the structure of interaction between institutions that should be outlined in the approach.

The main criticism that we address to the NSI literature is that it stops halfway towards an institutional theory of innovation and production systems. There is no theory of the boundaries of the system taken into consideration but an ad-hoc approach which adapts the frame of the analysis to the special cases under consideration. Most NSI approaches are focusing on the set of activities which are explicitly commonly linked with innovation. But the third point above hints at the fact that this chain may be expanded very broadly indeed! Things tend effectively to become more complicated and open to take into account all kinds of institutions if one counts among the activities involved in the innovation process all kinds of learning

processes. Hence the limits of the distinction between narrow and broad definitions of IS put forward by Lundvall whereby:

- the former limits itself to the areas of science, research, technology and in some cases education.
- the latter extends to all economic structures and institutional set-up affecting the production system and innovation.

The NSI literature is thus confronted to a twin-problem. If on the one hand it limits itself to a narrow definition of IS and focuses on innovation and technology and the behaviour of firms, it relinquishes thereby any ambition of an analysis of a macro-system. If on the other hand it takes into account a broader view and opens its analysis to the consideration of non-technological domains which indirectly influence the creation of technology, it faces the problem of the boundaries of the system under study. Extending the range of influences on technology sooner or later leads to having a theory of capitalism. It can be argued that having a sectoral logic, i.e. starting from a certain field (technology) in the analysis of modern capitalist economies, is possible, but takes as implicit that the chosen field exerts a dominating influence on the economic system, on its structure and on its dynamics. This more or less implicit assumption needs to be explicitly spelled out and justified.

In its logic, the broader view of NSI is even open to what we shall call general-purpose institutional approaches. These approaches relate the whole institutional architecture of an economy to its main economic characteristics in order to account for the long-run evolution of various modes of production. Their specificity is precisely a policy of including all institutions in a small number of categories, whatever their function is, from governing work to leisure, providing education and health but also ensuring central government activities. The vintage *régulation* approach is one such approach. It organises the analysis of activities around five sets of relationships: the wage-labour nexus, the forms of competition, international relations, money, and public authorities. The relations between these five forms characterise the overall mode of *régulation* of the economy.

The role of technology in this theoretical set-up is somehow at the interplay between the productivity and demand regimes. It conveys a dynamics of innovation close to that sketched by Kaldor in the description of his cumulative causation model. In that sense it is very specific to a period and a set of countries. Regarding the fordist regime it stresses altogether the development of increasing returns mainly based on scientific organisation of work within large firms and a monitoring of demand by means of new modes of market intermediation, as provided by restructured large service networks. The view it takes of technology is thus more comprehensive than usual as it concerns not only the production processes but also the infrastructures monitoring demand formation. The drawback is that the very process of innovation seems to be diluted altogether with general matters of organisations on the supply and demand sides.

It follows that if general-purpose approaches help to give a general frame to the whole institutional context of innovation, these frames remain rooted to one historical phase and under specified in terms of the diverse components that actually explain why growth rates differ. To follow the dynamics of growth and innovation in a comparative way, for countries which have all experienced a similar shift towards a new growth regime it is important to be more specific about the ingredients of success. These are likely to depend on the matching between long term characteristics of countries and the requirements of the contemporary regimes. There is clearly a need to combine the very long term cultural view underlying some NSI approaches with the requirements of contemporary regimes that a vintage regulation is stressing, if one wants to analyse national trajectories and design relevant policies to sustain economic growth.

Other theories retaining more specific subsets of subsystems are less open to such criticisms and may represent, in view of the two objectives set above (e.g. account for the requirements of contemporary regimes and take advantage of historical national traits) good compromises. To avoid the *charybde* of a narrow delineation of the relevant institutional context, which will miss a large part of the influence of the institutional fabric involved, and the *scylla* of a representation of the whole fabric of institutions, too broad to compare national trajectories on the issue, one can choose to select a subset of systems as the proper description of the relevant institutional context.

To compare these reasonably selective approaches and assess their relevance in accounting for the dynamics of innovation and growth, one cannot simply appreciate how complementary the activities selected are. It becomes clear at this stage that on top of complementarity between *activities* (which is already filtered by some vision of the world) the selection among institutions intends to focus on some specific governance

issues. In other words to strike a balance between a fully comprehensive approach of the institutional context and a fully comprehensive approach of all the activities directly involved in the process of innovation, a small number of determining issues have in each case be retained. Criticisms addressed to such a selection will then bear on the coherence of the choice made.

An example is given by the analysis in Amable, Barré and Boyer [1997] in terms of *Social systems of innovation and production*. In the empirical analysis, twelve developed countries were classified according to their institutional characteristics in six sub-systems: *Scientific activities (academic science)*, *Technological and innovative activities*; *Productive activities*, *Labour market activities*, *Education and training activities*; *Financial activities*. The six sub-systems define *Social Systems of Innovation*. Emphasis is thus put on the fact that interaction between institutional contexts is not limited to the science and technology system but encompasses also the effects of the institutional setting prevailing in other sub systems. Such an intermediary approach based on a subset of (sub)systems improves our understanding of the various growth patterns of contemporary economies. They also raise issues of interest regarding the selection of subsystems one should operate as well as the validity over time and across countries of these approaches. In other words the selection depends on the question raised, but also on the period and the countries. Some assumptions on the interactions between institutions (or between institutional contexts) were also revealed.

The results of the analysis was that four ideal-type models of innovation and production systems could be isolated (market-based, meso-corporatist, social-democrat and public/European integration). The different countries could be associated with one ideal-type, but a specific national model or national system was not the ideal-type itself. More importantly, the logic behind the construction of the ideal-types was neither sectoral (technology) nor national, but was based on the complementarity between institutions that influence economic behaviour.

### **Institutional complementarities**

We argue that the notion of system of innovation and production makes sense only when enlightened by a theory of institutional complementarities. In fact, every systemic view of the modern economies has implicitly or explicitly a theory of complementarity between activities.

A zero-level of complementarity can be associated with a selection of institutions directly induced by a selection of connected activities. The connection between activities may seem a straightforward notion as it refers to activities effectively directly interacting in some transactions. The institutions “monitoring” these activities appear thus ‘de facto’ connected, which may constitute a notion of ‘weak’ complementarity. This notion is used in NSI approaches, although not necessarily claimed for. The NSI itself is then an extension of the activities (and institutions) connected to the technology field.

A first genuine and specific notion of institutional complementarity corresponds to the case where two or several institutions may have a joint effect on, say, macroeconomic performance or more generally on the shape of the growth trajectory. Such interrelations may occur in different ways. The existence of one institution can thus make the others more efficient with respect to the system taken as a whole. Each institution or mode of organisation defines a set of constraints, incentives and possibilities that will determine agents’ strategies. The point is that the final impact of one institution on some economic issues is reinforced when the other complementary institution is present. In other words, one institution, or one system if there is an isomorphism between systems (finance, education, etc) and institutions, functions all the more efficiently when the other institution is present.

A related notion of institutional complementarity refers to the relations between the deliberative and enforcement aspects of ‘rules’. The co-existence of two institutions (regardless of the issue which they are directly connected to) may reinforce or hamper the application of the rules, but totally independently from the consequences of the applications of each rule. The emphasis is no so much on the relationship between an action and its consequences but on the rule and the action. For instance the rules of transparency practised in one institution are re-enforced if used in other institutions. Similarly, the criteria of tax exemptions retained in, say, education and health institutions will be more systematically applied and less likely to be changed if widely shared. This complementarity relates to the syntax of the ‘rules’ that institutions represent. It thus has a cognitive dimension which has some analogy with the problem raised by changes of preferences when evaluations in a decision process are made separately or jointly.

To clarify the two categories of effective complementarity between institutions, we can feature them in a scheme of decision where agents are first structuring their scope of actions, and second acting according to this frame and the conditions set by external influences. In the first phase of this decision process agents

somehow figure out the rules of the games. What the frame of their action will be depends on their perception of the relevance and the conditions of application of a whole set of institutions. The second phase is more classic and actions are taken within the previous frame in response to what the external conditions turn out to be. Complementarity at this last stage implies that the coexistence of different rules of decision influence the outcomes. Complementarity at the level of structuring the frames of actions means that the perception of the “syntax” of one rule influences in specific ways the perception of others. Briefly speaking, complementarity of type 2 refers to interactions in the understanding of the rules, while complementarity of type 1 refers to the cumulative or detrimental effects at the level of the outcomes of actions.

This notion of complementarity, in its true forms is fundamental in asserting the coherence as well as the pattern of evolution of an economic system. The ‘coherence’ of a system is then the ‘macro’ expression of the complementarity between specific institutional forms and the outcome in terms of economic performance (growth, employment,...). It differs across systems according to the type of complementarity.

One does not consider the isolated influence of one institution on a specific area of the economy (technology for instance), but the joint effect of a series of institutions and modes of organisation on the whole economy. Different structures of institutions may thus ‘perform’ roughly the same -in terms of an economy’s growth rate for instance- in spite of having separate components which may look very different when compared to one another because the relative efficiency of an institutional structure depends on the way the different components operate together. Just as one particular institution defines a set of constraints, possibilities and incentives for individual agents, several institutions will define a set of interrelated incentives which are going to jointly influence the individual agent’s behaviour. It is therefore logical to take into account the structure formed by several institutional arrangements rather than isolated institutions, with the hypothesis that the institutional structure defines the coherence of a ‘national model’, a historical phase of development, a system of production, etc. To put it in a different way, the various institutions, patterns of organisation, rules, norms, conventions... of an economy are not a more or less random collection of non-market arrangements. The presence of a particular institution, in a particular form, may or may not be compatible with the presence of another. The conditions for its existence and the relative efficiency of an institution -according to economic criteria- must then be determined by taking into account a large set of institutional arrangement, not just one institution alone.

The basic hypothesis is therefore that, several institutions -in the broad sense- taken together reinforce each other so that they form a coherent and stable but not everlasting structure. Sticking to a macro point of view, this structure shapes the growth trajectory or the general features of an economy. The aggregate coherence given by a set of institutions is defined by the complementary character of institutions. The concept of complementary institutions is based on multilateral reinforcement mechanisms between institutional arrangements: each one, by its existence, permits or facilitates the existence of the others. Sticking to the static equilibrium defined by a particular structure of institutions, the constraints and possibilities defined by a given institution favour other institutions’ functioning. Complementary institutions make one another more or less efficient according to their respective characteristics.

This complementary character is fundamental for defining the coherence as well as the pattern of evolution of an economic system. The ‘coherence’ of a given system -a ‘national’ model for instance, defined as the set of interrelated national institutions- is then the expression of the complementarity between specific institutional arrangements and the outcome in terms of economic performance (growth, employment,...).

### **Dynamics of systems of innovation and production**

The consideration of institutional complementarities almost inevitably implies putting the emphasis on statics first. But this is only a moment in the analysis, and should not be taken as a sign that the theory itself necessarily involves a static vision of capitalism in its variety.

Most definitions of institutions effectively encompass a strong time dimension, they imply some repetition and stability over time. Still this does not rule out the idea of evolution and change or even disappearance. An extension of the notion of static complementarity among institutions considers the possibility of reinforcement or weakening over time. Still this more dynamic perspective does not transform much our appreciation of systemic coherence, unless one wants to pay attention to the possibility of a breakdown of a set of institutions -for instance of a given national model or an innovation system -. The static notion emphasises coherence and stability, the dynamic one allows for the emergence and disappearance of this coherence.

At this stage a distinction could be made among approaches between the analyses seeing the architecture of institutions as so coherent that they could be featured as a solid block, specific to each nation, forged all along its history and those that allow for a more or less extensive separability of the effects of various sub sets of institutions .

- National institutions may be seen as so coherent as to constitute one block with components so tightly coupled that one speaks readily of one institutional infrastructure. A dynamic perspective would help to assess the only valid question in this case, i.e. the viability of this national institutional infrastructure. Culturalism would correspond to the extreme assumption that this infrastructure is near-eternal or unexplainable by economists. In this case, two positions are compatible with such a point of view: (i) one may consider that institutions are more or less neutral with respect to economic performance, so that economic change occurs without affecting the specificities of national models of capitalism; these specificities are little more than folklore and national economies may evolve without changing this folklore. Dominant technologies or forms of organisation diffuse internationally and adapt to the country specificities without being significantly altered. (ii) One considers on the opposite that the specific institutional infrastructure exerts a prominent influence on economic dynamics. If there is a dominant technology or form of organisation which is incompatible with the existing institutional structure, the national model or system does not change but breaks down.

- Alternative approaches effectively assume a more or less important possibility to separate between the effects of subsets of institutions. Such separability is important in terms of economic policy. It helps to feature how institutional change can be monitored. In that respect cohesive forces between institutions are not uniformly distributed and any attempt to monitor institutional change must preliminarily explore these rankings.

The notion of institutional complementarities links together different institutions and modes of organisation in a certain architecture. A notion of *hierarchy* of institutions insists on the relative importance of one or a few institutions for the architecture as such. In a static perspective, hierarchical relationships define a link between institutions and should therefore be explored starting with the different kinds of complementarities that we have distinguished. Still it is difficult to assess an asymmetry in the two kinds of complementarity relationships that we defined above.

One needs to take a more dynamic perspective in order to introduce asymmetries between institutions. The asymmetry could be that one institution changes when the other does not. A more genuine hierarchical relationship would stem from the fact that changes not only occur in one institution but do induce changes in other institutions. The changes may concern the conditions and rules of application of an institution or the way in which it affects economic issues. Transformations of specific institutions may be difficult to conceive and to follow comparatively. Such dynamics may be more relevant when applied to sub sets of “coherent” institutions. The above exposed analysis of the relationships that structure the fabric of national institutions leads to some important implications. First the role of one or a few institutions cannot be isolated from a context, if only of other institutions. The way in which institutions influence behaviour in one field may well relate to the existence of complementary institutions. These complementarities can take place at various levels. One is directly linked with the impacts of institutions on economic issues (the increase in employment, the stimulation of innovation and growth). The other concerns the level of the implementation of the rules corresponding to the institutions under view. In other words one level deals with the semantics of institutions, the other with the syntax of institutions. Both relationships have similar implications. To appreciate the impact of one institution one has to take into account the graph of connections that these complementarities imply. It is difficult to say a priori whether this graph is far ranging or not. Some connections may be stronger than others so that one could well imagine considering only the connections which have a certain weight. All these considerations are important when one assumes that institutions matter in most aspects of economic activities. In some cases this statement amounts to recall the importance of fundamentals which cannot be altered or transferred. In some other cases it seems that institutional changes can be undertaken and are part of the policy tools.

Such seems to be the case regarding the innovation capability of a country. The central role of this capability in determining the competitiveness of countries helps to suggest that institutions supporting the dynamics of innovation can somehow be copied and transferred. Our argument stresses that such reverse engineering could be very misleading if one did not take into account the various complementarities conditioning both the implementation and the impact of institutions.

Even if one accounts for these complementarities, it is still difficult to know what will come out of a policy transferring a full set of institutions from one country to another. Almost by definition, the notion of institution is strongly linked with an idea of habits and repetitions. Therefore a policy to import institutional changes has to be especially cautious. One is forced to take a more dynamic perspective to clarify the issue, to see how the implant will fare. It may also be the case that institutions gain new properties in the process and lose some others. A dynamic perspective led to discover that asymmetric, hierarchical relationships between institutions could occur. All of which shows the complexity of policies that plan to reproduce some institutional context. Investigating the structure of the national fabric of institutions may help to reduce the problem posed by the complexity of the laws of institutional change. It can lead to some pragmatic principles which would help to some broad targeting of objectives.

### 3.1.2. TIK results and activities

#### **The concept of institutions within systems of innovation-approaches (Terje Grønning).**

The objective of this sub-project was to contribute to the analysis and synthesis of the theoretical reasons for a leading role of institutions in the genesis and diffusion of technical change.

#### **Methodology**

The methodology was to analyse selected existing theoretical literature. The emphasis has been on literature within economics and sociology, and otherwise relevant literature within political science has thus been excluded. Focus was on the theoretical set-up of systems of innovation approaches. In concrete terms this issue was pursued by way of examining the concepts in use within this specific approach with the concepts in use within the "new institutionalism" debate within economics and sociology.

#### **Scientific Findings**

The concept of institutions is crucial within the systems of innovation kind of analytical approach to innovation issues, since the existence, absence of, or character of specific, existing institutions is being interpreted as potentially conducive v obstructive to innovation processes. In parallel with the emergence of a systems of innovation approach there has been a discussion debating "new" v "old" institutionalism within the social sciences. This debate is hardly being mentioned within the systems of innovation literature. In a comparison of the theoretical set-up of the systems of innovation literature and the literature within the "new institutionalism" debate it turns out that systems of innovation-approach tends to be "old" institutionalist in the sense of not focusing as much on cognitive aspects as the "new" institutionalism. Within the systems of innovation-approach there tends in contrast an understanding of institutions as predominantly regulative phenomena. The systems of innovation approach does, however, follow the "new" institutionalist idea of having an overall distinction between "institutions" and "organizations" in its analysis.

#### **Policy Implications**

Only general policy implications can be drawn since the sub-project is exclusively theoretical in its orientation. However, being aware of the fact that the systems of innovation approach has hitherto operated predominantly with a regulative understanding of institutions is indispensable to policy-making, since such an understanding is more focussed on the ways institutions influence action rather on the issue of how the institutions came into being in the first place. Alternative conceptualizations of the nature of institutions may be necessary in the case when policies are preoccupied with the dynamic evolution of institutions and hence with the interplay between institutions and action.

## 3.2. Structure and stability of systems of innovation in 22 countries (Work Package B)

### 3.2.1. OST research results and methodology on typology and dynamics of Social Systems of Innovation and Production National: what perspectives for the European Research Area ?

#### A. Objectives

Given the current state of European integration and internationalisation, social systems of innovation and production (SSIP) are evolving and the major aim of the workpackage is to assess the impact of structural changes upon the diversity and global performances of these coexisting innovations system. The main point to be investigated concerns the viability of social systems of innovation and production and their transformations under the process of European integration and more international dependence.

#### **Questions addressed and aims**

The aim is to explore quantitatively the diversity of innovation systems in Europe using a variety of sources and to assess their transformations during the two last decades.

The questions addressed are the following:

- are there different configurations ? if yes how can they be characterised ?
- what is the dynamics of these configurations ? are they stable over time ? do they converge or diverge ?
- is the dynamics different for different sub-systems ?
- is there a specific pattern for EU countries ? what could that mean for the European Research Area ?

We want to assess the diversity of national systems of innovation and production observed in Europe and what is their dynamics. We aim here at an overall perspective of the notion of SSIP, at characterising the diversity of systems existing in Europe and elsewhere, in order to give broad views of the SSIP of some European countries.

#### **Operational objective: to update and extend a taxonomy for social systems of innovation and production and characterise their dynamics**

The operational objectives are:

1. to survey a large number of possible SSIP parameters and select them in terms of the availability and quality of data,
2. to establish a typology of Social Systems of Innovation and Production (SSIP) and characterise different types, thus re-visiting the previous taxonomy of social systems of innovation established by Boyer, Barré, Amable [1997],
3. to provide a dynamic perspective for these Social Systems of Innovation and Production over the period 1986 - 96,
4. to deepen the analysis by explaining the overall structure, typology and dynamics by the role of various sub-systems.

B. Method: survey of possible SSIP parameters and selection in terms of the availability and quality of data, data analysis performed

The approach consists in data analysis and clustering for various sub-systems. The analysis concern 22 countries from Europe, North America and Asia at three dates (1986, 1991, 1996).

### ***The candidate parameters / variables***

Around 500 candidate parameters / variables have been explored to characterise the various components of the systems of innovation and production.

### ***The criteria for selection of the variables***

To be useful for the analysis, the variables had to satisfy the following criteria :

- availability for 22 countries: the 15 EU countries, plus Switzerland, Norway, the United States, Canada, Japan, Korea and Australia,
- at the three dates 1986, 1991, 1996,
- with good comparability among dates and countries,
- with relevance for inclusion in one of the sub-systems.

Few data satisfied the criteria<sup>4</sup>, and in fact only 64 variables could be finally selected.

Important result: variables relevant for understanding the systems of innovation and production, that is, allowing for 10 year period description of about twenty countries in an homogeneous way, are very scarce indeed.

### ***The sub-systems and the variables***

After review of the available and relevant data, we break up the SSIP in eight sub-systems:

1. volume and funding of R&D activities
2. scientific specialisation
3. industrial R&D profile
4. technological specialisation
5. economic activities profile
6. labour market and social protection
7. education
8. macroeconomic and social performance

#### **1. Volume and funding of R&D activities**

variables of sub-system 1 - volume and funding of R&D activities

GERD/GDP\*

Scientific Publications (Number of)/GDP\*\*

Civil financing of GERD/GDP \*

Military financing of GERD/GDP \*

Execution of GERD in public research/GDP \*

BERD/GERD\*

Financing of GERD by the business enterprise sector/GDP \*

% of BERD financed by the business enterprise sector\*

Invented patents (number of)/GDP \*\*\*

Sources: OECD-PPI\*, SCI-ISI\*\*, INPI-EPO\*\*\*

GERD: Gross expenditure on RD ; GDP: Gross domestic product

BERD: Business expenditures on RD

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<sup>4</sup> some data were missing for Switzerland, Luxembourg, Korea, and Ireland

## 2. Scientific specialisation

variables of sub-system 2 - scientific specialisation

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Publications, Scientific Specialisation Index, Fundamental biology  
Publications, Scientific Specialisation Index, Medical research  
Publications, Scientific Specialisation Index, Applied Biology-Ecology  
Publications, Scientific Specialisation Index, Chemistry  
Publications, Scientific Specialisation Index, Physics  
Publications, Scientific Specialisation Index, Space and earth sciences  
Publications, Scientific Specialisation Index, Engineering sciences  
Publications, Scientific Specialisation Index, Mathematics

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Sources: SCI-ISI

Scientific specialisation index: world share of publications of a country in a discipline divided by the world share of this country all disciplines together

## 3. Industrial R&D profile

variables of sub-system 3 - industrial R&D profile

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Share of Aerospace in BERD  
Share of Electronics in BERD  
Share of Pharmacy in BERD  
Share of Equipment in BERD  
Share of Land transportation in BERD  
Share of Chemistry in BERD  
Share of Natural Resource Intensive in BERD  
Share of Labor Intensive in BERD

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Sources: OECD-ANBERD.

BERD: Business expenditures on RD

## 4. Technological specialisation

variables of sub-system 4 - technological specialisation

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Invented patents, Technological Specialisation Index, Electronics-electricity  
Invented patents, Technological Specialisation Index, Instrumentation  
Invented patents, Technological Specialisation Index, Advanced chemistry-pharmacy  
Invented patents, Technological Specialisation Index, Processes-basic chemistry-metallurgy  
Invented patents, Technological Specialisation Index, Machines-mechanics-transportation  
Invented patents, Technological Specialisation Index, Household consumption-construction

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Sources: INPI-EPO.

Technological specialisation index: world share of patents of a country in an area divided by the world share of this country all areas together

## 5. Economic activities profile

variables of sub-system 5 - economic activities profile

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VA of Agriculture as % of GDP\*  
VA of Industry as % of GDP\*  
VA of Services as % of GDP\*  
VA of Finance, insurance, real estate and business services as % of GDP \*\*  
VA of Community, social and personal services as % of GDP \*\*  
VA of Producers of government services and other producers as % of GDP \*\*  
VA of Aerospace as % of GDP \*\*\*  
VA of Electronics as % of GDP \*\*\*  
VA of Pharmacy as % of GDP \*\*\*  
VA of Equipment as % of GDP \*\*\*  
VA of Land transportation as % of GDP \*\*\*  
VA of Chemistry as % of GDP \*\*\*  
VA of Natural Resource Intensive sectors as % of GDP \*\*\*  
VA of Labor Intensive sectors as % of GDP \*\*\*

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Sources: WMF\*, OECD-NA\*\*, OECD-STAN\*\*\*

VA: value added

GDP: Gross domestic product

## **6. Labour market and social protection**

variables of sub-system 6 - labour market and social protection

Non wage labour costs as a % of total labour costs

Rate of union membership

Collective agreement coverage

Precariousness feeling

Seniority inferior one year

Seniority superior 20 years

Expenditure of hiring aid/GDP

Expenditure of unemployment indemnity/GDP

Sources: OECD-Employment Outlook.

## **7. Education**

variables of sub-system 7 - education

Higher Education Enrolment\*

Public expenditure on education per capita\*

Graduates, upper secondary level\*\*

Graduates, non university tertiary level\*\*

Graduates, university level\*\*

Public expenditure on education as a % of total public expenditure\*\*

Sources :WMF\*, OECD-Education at a glance\*\*

## **8. Macroeconomic and social performance**

variables of sub-system 8 - macroeconomic and social performance

GDP per capita\*

Rate of unemployment\*\*

% of household income going to lowest 20% of households\*\*\*

% of household income going to highest 20% of households\*\*\*

Sources: OECD-NA\*, OECD-ALFS\*\*, WMF\*\*\*

The various sub-systems can be considered as components of the Social System of Innovation and Production.

### ***The data analysis performed***

1. the typology of the SSIP of the countries described by 64 parameters (1996)

The typology results from a clusterisation of the countries built on the distances between each pair of countries.

The countries are split into groups by cutting the hierarchical tree of the distances among countries at an appropriate level. Each group is said to be an SSIP 'type'.

The profile of each type is defined by a value on each one of the 64 parameters, which is the mean value of the parameters of the countries constituting the type.

2. analysis of the dynamics of the types (1986-1996)

Our unit of analysis is the SSIP type as identified above, defined as the mean of the countries which constitute it. Each SSIP type has a position in the space of the parameters defined as the mean value of the parameters of each constituting country of the type.

We will study the dynamics by 'projecting' the SSIP types with the value of the parameters for year 1986 into that same factorial space, defined for year 1996. Each SSIP type will have thus a representative point for year 1986 and for year 1996.

Studying the dynamics consists in analysing the moves of the representative points of the SSIP types at 2 dates in the 1996 factorial space, usually the first plane.

c. Results 1: typology of the Social System of Innovation and Production (SSIP) of 18 countries identifying a EU-Area SSIP model static analysis (year 1996)

a. The typology of the countries as characterised by their 64 parameters (1996)

The typology results from a clusterisation of the countries built on the distances between each pair of countries. The countries are split into 7 groups. Each group is said to be an SSIP 'type'. Each group / type is given a label of geo-political nature (table 1-1).

**Table 1-1 – the geopolitical labelling of the seven SSIP types**

Type	countries (year 1996)	Geopolitical label
1	Australia, Norway	Natural resources
2	United-States, United-Kingdom, Canada	Anglo-Saxon
3	Belgium, the Netherlands, Denmark	EU-North sea
4	Finland, Sweden	EU-Nordic
5	Germany, France, Italy, Austria	EU-core
6	Japan	Japan
7	Spain, Greece, Portugal	EU-Mediterranean

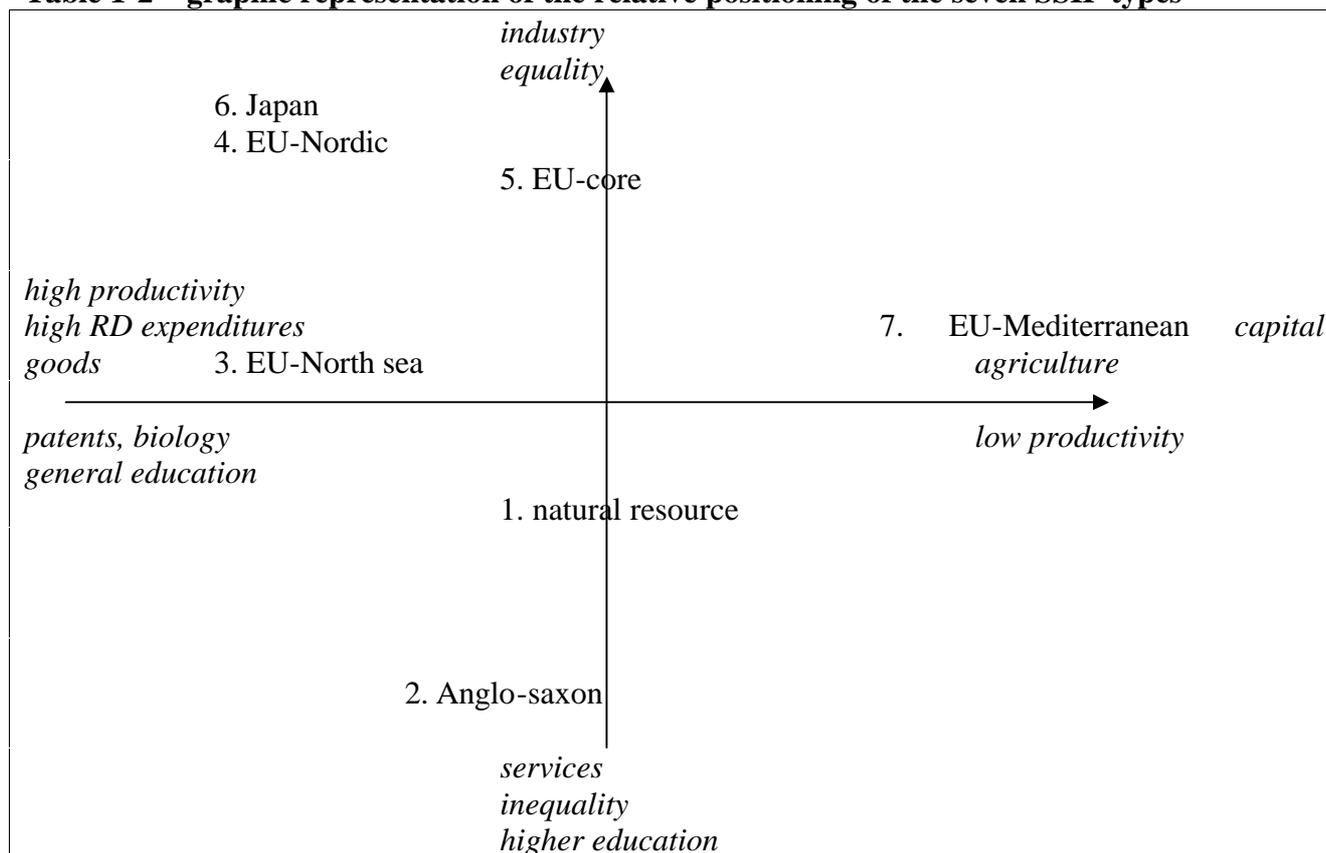
b. Characterisation of the seven SSIP types

i. The definition of the axis of the first factorial plane

The data analysis of the 18 countries described by 64 parameters for year 1996 can be synthesised by the identification of the first 2 axis of the factorial analysis as defined below (see table 1-2). The first axis accounts for 21,98 % of the total variance, the second axis for 15,85 %.

ii. The positioning of the seven SSIP types in the first factorial plane

**Table 1-2 – graphic representation of the relative positioning of the seven SSIP types**



### iii. The description of the seven types on the parameters

Natural resources (type 1) has a rather low innovative activity (GERD/GDP, BERD/GDP, patents/GDP) and financing of RD by the business sector. This group has strong medical research and earth (geology) – ocean scientific specialisation. The structure of economic activities is characterised by a relatively large share of services .

The education sub-system exhibits a large public expenditure on education per capita and as % of public expenditure, as well as a high level of graduates of the university tertiary level. Type 1 has a high level of GDP per capita.

Anglo-Saxon (type 2) is characterised by rather strong RD activities (GERD/GDP and BERD/GDP). However, the number of invented patents relative to GDP is relatively weak. The scientific specialisation is in life sciences and earth-ocean-universe sciences. A high share of services in GDP characterises the structure of economic activities.

On the labour market, the rate of union membership, seniority superior to 20 years and expenditures for unemployment are very low whereas the precariousness feeling is strong. The education sub-system is defined by a high level of graduates at university level. GDP per capita is high and the income distribution is unequal.

EU-North sea (type 3) has an average level of RD activities. Its scientific specialisation profile is dominated by biology and medical research. It has a rather large share of services activities, but relatively modest ones regarding industry.

The labour market sub-system exhibits a rather high rate of union membership. On the education side, this type is characterised by large public expenditure on education per capita and graduates of the university tertiary level. GDP per capita has an average level and income distribution is rather egalitarian.

EU – Nordic (type 4) is characterised by a high level of both public research and industrial research and innovative activities (GERD/GDP, BERD/GDP, number of invented patents/GDP, business RD relative to national RD, financing of RD by the business sector, execution of RD in the public sector relative to GDP). Its scientific specialisation profile is dominated by biology and medical research. The structure of economic activities is characterised by large shares of Industry and Equipment goods sectors in GDP.

The labour market sub-system is defined by a large rate of union membership and expenditure for unemployment. On the education side, public expenditure on education per capita is very high. GDP per capita is average and the income distribution is egalitarian.

EU-Core (type 5) has an average RD activity. It is specialised in chemistry, physics and mathematics. The structure of economic activities exhibits a high share in the equipment goods sector. Education shows relatively low levels of graduates of the university tertiary level and public expenditure on education as % of public expenditure, but the level of graduates of the upper secondary level is strong. This type has average values as far as GDP per capita and income repartition are concerned.

Japan (type 6) is characterised by high level of innovative activities in the business sector. (high level of financing of GERD in the business sector). Its scientific specialisation is dominated by physics and chemistry. The structure of economic activities is characterised by weak shares of both Services and Agriculture, high shares of Industry, especially the Electronics and Equipment goods sectors.

Seniority superior 20 years is high. Higher education enrolment and Public expenditure on education as % of public expenditure are weak. GDP per capita has a high level.

EU-Mediterranean (type 7) is characterised by weak research and innovation activities. Its scientific specialisation profile is strong in engineering sciences, mathematics and chemistry. The economic activities structure exhibits a high share of agriculture, a low share of both services and electronics and equipment goods sectors.

On the labour market side, this type has a very weak rate of union membership. Education variables are all at a low level. GDP per capita is low and income repartition is rather unequal.

### c. Relating the seven types to the SSIP models defined in Amable, Barré, Boyer (1997)

i. The four SSIP models defined in Amable, Barré, Boyer (1997)

The results of the present empirical study can be fruitfully compared to the results of the study realised in Amable, Barré, Boyer (1997). In this latter study, a typology of social systems of innovation had been realised considering twelve countries in 1992. The factor analysis and analysis of distance led the authors to classify countries into four groups that correspond to four different social systems of innovation:

- the market-based model: United-States, United-Kingdom, Canada and Australia,
- the social democrat model: Sweden, Norway, Finland,
- the public-institutions-based model: France, Germany, Italy, the Netherlands,
- the meso-corporatist model: Japan.

ii. Correspondence between the seven types and the four SSIP models defined in Amable, Barré, Boyer (1997) – reference to country groupings

**Table 1-3 – correspondance in terms of country groupings between the seven types and the SSIP models defined in Amable, Barré, Boyer (1997)**

Type	countries (year 1996)	geopolitical label	reference to SSIP model in Amable, Barré, Boyer (1997) in terms of country groupings
1	Australia, Norway	natural resources	(not existent)
2	United-States, United-Kingdom, Canada	Anglo-Saxon	market based
3	Belgium, the Netherlands, Denmark	EU-North sea	public institutions based
4	Finland, Sweden	EU-Nordic	social-democrat
5	Germany, France, Italy, Austria	EU-core	public institution based
6	Japan	Japan	meso corporatist
7	Spain, Greece, Portugal	EU-Mediterranean	(countries not included)

iii. Interpretation of the four SSIP models defined in Amable, Barré, Boyer (1997) in terms of the seven types– based on country groupings and analysis of distances among types

Considering the four models defined in Amable, Barré, Boyer (1997) as relevant archetypes, we relate the seven types to these archetypes considering the distances among the seven types (table 1-4).

**Table 1-4 - interpretation of the seven types in terms of the four SSIP models defined in Amable, Barré, Boyer (1997)**

SSIP model in Amable, Barré, Boyer (1997)	type	countries (year 1996)		
Public institutions based	5	Germany, France, Italy, Austria	EU-core	public-institutions-based model
	3	Belgium, the Netherlands, Denmark	EU-North sea	variant of the public-institutions-based model for very developed countries of rather small size and strong internationalisation
	7	Spain, Greece, Portugal	EU-Mediterranean	variant of the public-institutions-based model for less developed countries, but with many specific features
Social- democrat	4	Finland, Sweden	EU-Nordic	social-democrat model, getting closer to the public- institutions-based model
Meso corporatist	6	Japan	Japan	meso-corporatist model, getting closer to the public- institutions-based model
Market based	2	United-States, United-Kingdom, Canada	Anglo-Saxon	market based
	1	Australia, Norway	natural resources	variant of the market based model for economies heavily determined by the exploitation of natural resources

- iv. Interpretation of the seven types in terms of the four SSIP models defined in Amable, Barré, Boyer (1997)– based on country groupings and analysis of distances among types

Using the results presented in table 5 above, it is possible to present the seven types in terms of the SSIP model and their variants (table 1-5).

**Table 1-5 – the seven types defined in terms of SSP model variants**

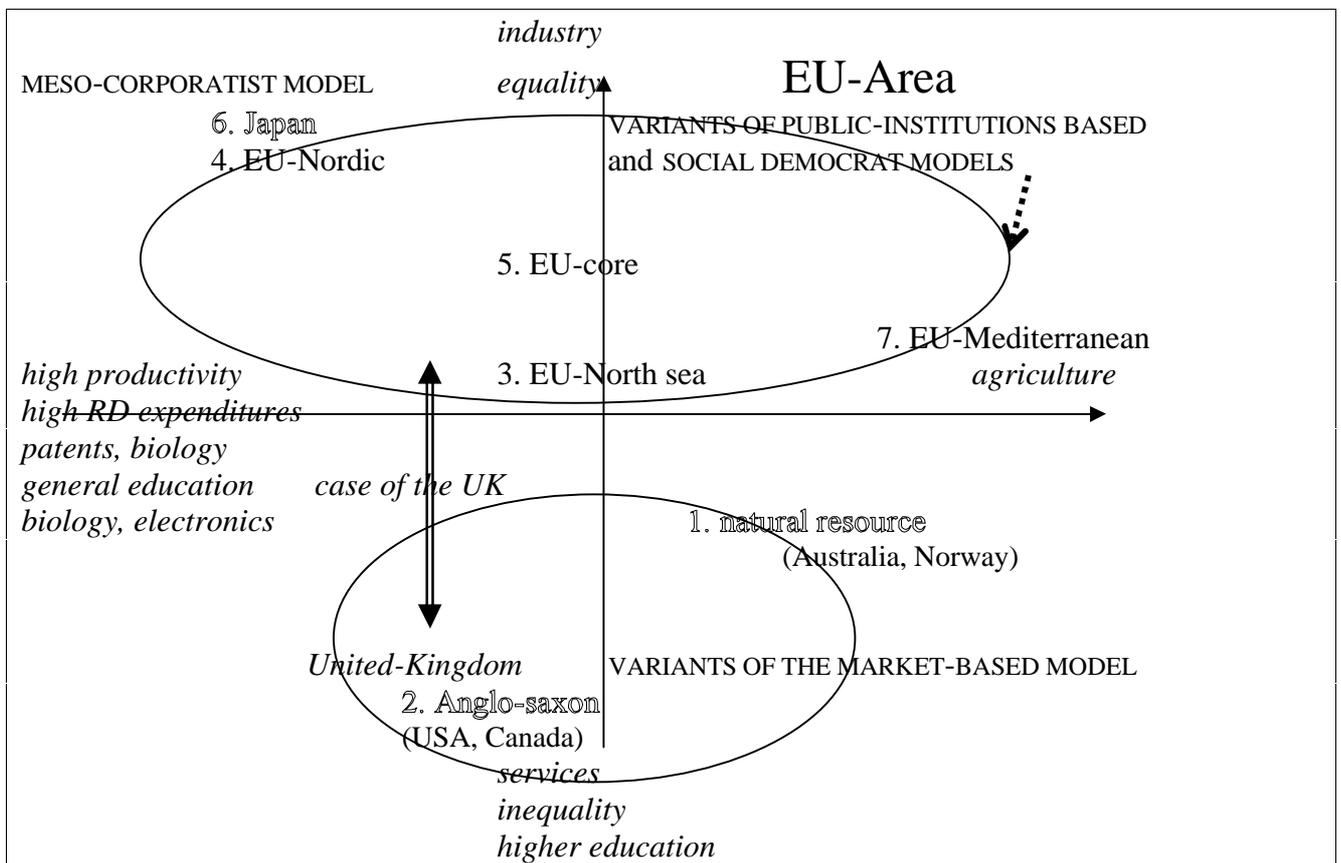
	countries (year 1996)	geopolitical label	related SSIP model	SSIP model variant
1	Australia, Norway	natural resources	market based	variant of the market based model for economies heavily determined by the exploitation of natural resources
2	United-States, United- Kingdom, Canada	Anglo-Saxon	market based	market based
3	Belgium, the Netherlands, Denmark	EU-North sea	public institutions based	variant of the public-institutions-based model for very developed countries of rather small size and strong internationalisation
4	Finland, Sweden	EU-Nordic	social-democrat	social-democrat model, getting closer to the public-institutions-based model
5	Germany, France, Italy, Austria	EU-core	public instit. based	public-institutions-based model
6	Japan	Japan	meso corporatist	meso-corporatist model,, getting closer to the public-institutions-based model
7	Spain, Greece, Portugal	EU- Mediterranean	public instit. based	variant of the public-institutions-based model for less developed countries, but with many specific features

d. Characterisation of the SSIP of the EU member states

i. An EU-Area model ?

EU countries appear in 5 of the 7 groups which is an indication of the diversity of the EU nations innovation and production systems. However, the groups of Japan (group 6), the USA, Canada (group 2) and Australia, Norway (group 1) are not positioned in-between EU-nations groups, but at the periphery of the first factorial plane. This means that on the whole, EU member states have more in common among themselves than with non-EU nations. In other words, EU member states are diverse, but they share some key-features, the UK having here a specific situation (see figure 1-4).

**Figure 1-4 – the relative positions of groups including or not including EU member states**



**Table 1-6 – the types in terms of broad models, including a tentative EU-Area model**

Broad model reference	type	countries (year 1996)	geopolitical label	SSIP model and their variants
EU-Area model (public institutions based model broadly defined)	5	Germany, France, Italy, Austria	EU-core	public-institutions-based model
	3	Belgium, the Netherlands, Denmark	EU-North sea	variant of the public-institutions-based model for very developed countries of rather small size and strong internationalisation
	7	Spain, Greece, Portugal	EU-Mediterranean	variant of the public-institutions-based model for less developed countries, but with many specific features
	4	Finland, Sweden	EU-Nordic	social-democrat model, getting closer to the public-institutions-based model
meso corporatist model	6	Japan	Japan	meso-corporatist model, getting closer to the public-institutions-based model
Market based model	2	United-States, United-Kingdom, Canada	Anglo-Saxon	market based
	1	Australia, Norway	natural resources	variant of the market based model for economies heavily determined by the exploitation of natural resources

ii. The characterisation of the EU-Area model

What do the EU member states have in common ? what makes the EU-Area different from the others ?  
 The EU-Area drawn on figure 1-4 shows that EU member states are all positionned with a positive value on the second axis of the factor analysis. This axis is characterized by the following features (see box 1-4).

**Box 1-1 – what the EU-Area SSIP variants of the public institutions based model share and do not share**

	EU SSIP types share	EU SSIP types do not share
• volume and funding of RD activities (sub-system 1)		- intensity of national RD expenditure / GDP, - intensity of civil financing of research and of public research / GDP, - intensity of scientific activity / GDP, - intensity of business RD / GDP - intensity of technological activity / GDP
• scientific activities profile (sub-system 2)	scientific specialisation in physics and chemistry	level of specialisation in biology and medical research, on one side, in engineering and mathematics, on the other,
• industrial RD profile (sub-system 3)	high proportion of national industrial RD in automobile, chemistry, equipment goods,	proportion of national RD in labour intensive sectors
• technological activities profile (sub-system 4)		level of specialisation in electronics, as opposed to household consumption goods
• economic activities profile (sub-system 5)	importance of industry and government services in GDP	proportion of agriculture and of electronics sector in GDP
• labour market - social protection (sub-system 6)	- employment stability (strong proportion of seniority above 20 years), - good compensation schemes for unemployed , - high non wage labour cost, - good collective agreements coverage, - important union membership	
• education activities (sub-system 7)		public expenditure on education per capita, % of graduates at upper secondary level
• macro-eco. and social perform (sub-system 8)	relatively evenly distributed income	GDP per capita and rate of unemployment.

e. Synthesis of results of the analysis for year 1996 and of the comparison with results from Amable, Barré, Boyer (1997)

*1. The SSIP models and types have a robust definition*

The comparison between the results from Amable, Barré, Boyer dealing with 1992 data and from this study show a relative stability of the SSIP types over time and over the choice of variables, which leads us to consider that the identification and characterisation of the SSIP types is quite robust.

Fundamentally, this is due to the existence of socio-political compromises and complementarity among sub-systems which do not allow for quick changes in the structural features embodied in a SSIP type.

*2. There is a good stability in the relationship between countries and SSIP model*

The countries are quite stable in their SSIP type between analysis with 1992 and 1996 data. The fact that S&T capabilities are accumulated over time, that technological trajectories are path dependent, that institutional forms are strongly resilient do explain this situation.

*3. Some structural evolutions or instabilities can be conjectured*

The social democrat and the meso-corporatist models are still identifiable in our analysis, but they come close to variants of the public institution based model. This may be due to evolutions of those models, or to the fact that they differentiate themselves by parameters not taken into account in the analysis.

*4. The EU member states share key features in their SSIP, allowing us to define a broadly defined EU-Area SSIP model, having much to do with the public institution based model*

The EU member states SSIP share almost all the parameters of labour market – social protection sub-system, as well as a relatively evenly distributed income and an important role of government services in GDP. They also share:

- a relatively important role of industry in economic activity,
- a high proportion of national industrial RD in automobile, chemistry, equipment goods,

- a scientific specialisation in physics and chemistry.

In brief, EU-Area SSIP are all characterised by significant redistributive functions aimed at social objectives and public services, particularly in relationship with the labour market. They are also all characterised by the importance of ‘classical’ industrial sectors (such as automobile, chemistry, equipment goods) and the intensity of their innovation activities in those sectors.

#### 5. Nevertheless, the EU-Area SSIP model has variants related to substantial differences

EU member states SSIP differ on GDP per capita and rate of unemployment, on all parameters of sub-system volume and funding of RD activities, and on most parameters of sub-system education activities.

They also differ in their:

- proportion of agriculture and of electronics sector in GDP,
- proportion of national RD in labour intensive sectors,
- level of technological specialisation in electronics, as opposed to household consumption goods,
- level of specialisation in biology and medical research, on one side, in engineering and mathematics, on the other.

Such differences are important enough to raise questions on the dynamics of the variants, as well as the conditions of a European research area.

#### D. Results 2: the dynamics of the Social Systems of Innovation and Production (SSIP) period 1986–1996

Our unit of analysis is the SSIP type as identified above, defined as the mean of the countries which constitute it. We have seven such SSIP types, with a ‘geo-political’ label, and a position in the space of the parameters defined as the mean value of the parameters of each constituting country.

##### a. The 1986 – 1996 dynamics of the seven SSIP types – overall view

Figure 2-1 shows the evolution of types between 1986 and 1996 on the first factorial plane.

- There is no overall convergence of the types but a combination of common trends and specific divergence points

Each type has co-ordinates on the factorial axis. The standard deviation of those co-ordinates on each axis is a measure of the distance, thus of the variety of the types. The spread of the positions of the types is slightly larger in 1996 than in 1986 on all three first axis of the factor analysis. This means there are specific points of divergence among types.

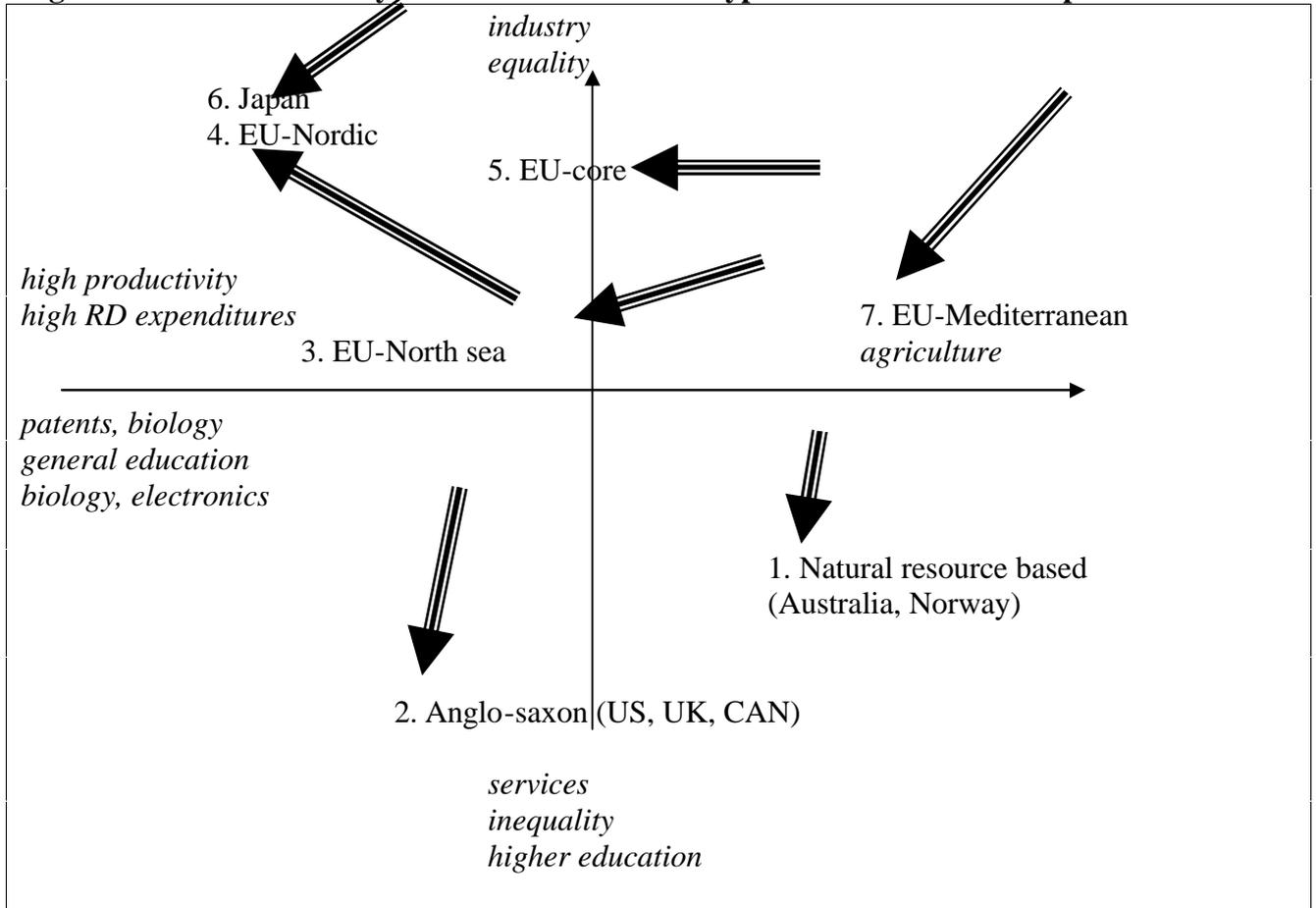
- The first common trend: the emergence of the knowledge based society

The move towards the negative side of the first axis means the following:

- higher RD expenditure both by firms and the State, as well as higher scientific and technological activity,
- more research, innovation and economic activity in biology and ICT based areas,
- higher Public expenditure on education, as well as higher proportion of upper secondary level graduates,
- higher GDP per capita.

This trend can be summarised as reflecting the the emergence of the knowledge based society, which concerns all types.

**Figure 2-1 – 1986 – 1996 dynamics of the seven SSI types in the first factorial plane**



iii. The second common trend: more inequality or more business services or more higher education ?

All types except type 4 (EU-Nordic) shift towards the negative side of axis 2. This side of axis two has basically the following meaning:

- large share of household income going to richest 20% of households (inequality) (subsystem 8), to be linked to lower social protection and less regulation of the labor market (sub-system 6),
- large share of economic activity in services, in particular into business services (finance, insurance, services to firms) (sub-system 5),
- importance of higher education enrolment (sub-system 7).

The question is to know which one of these meanings is responsible for the shift of the various types, in particular those involving EU-countries.

b. Understanding the second common trend of the variants of the EU-Area SSIP model: analysis of the dynamics at the level of the sub-systems

Given the variety of parameters behind axis 2, the general trend exhibited by all SSIP types (except the EU-Nordic) towards the negative side of the axis could be interpreted as more inequality or more business services or more higher education. We will test these 3 hypothesis

i. Increasing inequality and lower social protection hypothesis (sub-systems 6 and 8)

*1) the lower social protection hypothesis (examination of the labour market and social protection - sub-system 6)*

The 1986 – 1996 trends show a clear move of EU countries types (except EU-Mediterranean) towards relatively more social protection and labour regulation, as well as a clear move of non EU types (Anglo-Saxon, natural resources and Japan) towards the opposite direction.

This leads to the conclusion that the trend for EU types is not towards lower social protection and lower labour market regulation, except for the EU-Mediterranean type. This is in sharp contrast with the other types.

*2) the increasing inequality hypothesis (examination of the macroeconomic and social performance - sub-system 8)*

The 1986 – 1996 trends show a clear move of all EU countries types towards relatively more income equality. This is also the case of the Natural resources type, but not of the Anglo-Saxon type, nor of Japan. On the second axis, all types exhibit a trend towards increased GDP per capita and less unemployment.

The conclusion is that EU types evolve towards relatively more income equality, in sharp contrast with the other types, except the Natural resources based type.

Finally, the hypothesis of a trend of the EU types towards increased inequality and less social protection is not valid. More precisely, the hypothesis is not valid for EU-types (with some reservations regarding the EU-Mediterranean type), but it is indeed valid for non EU types.

ii. *The increasing activity in business services hypothesis (examination of the economic activities profile - sub-system 5)*

The 1986 – 1996 trends show a general move of SSIP types towards a lesser share of industry in GDP (except EU-Nordic) and towards a larger share of business services.

The conclusion is that the hypothesis is valid and that all EU-types move indeed towards an increasing importance of business services in economic activity.

iii. *The increasing importance of higher education hypothesis (examination of the education sub-system - sub-system 7)*

The analysis of the dynamics of the types in the first factorial plane show that all types evolve significantly towards more higher education enrolment, and also towards more public expenditures per capita, except the Anglo-Saxon type.

The conclusion is that the hypothesis is valid: all EU-types evolve towards more higher education enrolment.

E. Synthesis of results of the analysis of the dynamics of the SSIP

1. There is no overall convergence of the types but a combination of common trends and specific divergence elements

2. The common trends: the emergence of the knowledge based society

a) All types exhibit the following evolutions :

- higher RD expenditure both public and private, increased scientific and technological activity (sub-system 1 – volume and funding of RD activities), particularly in biology and information based areas (sub-system 2 and 4 – scientific and technological activities profile),
- higher public expenditure on education, increasing proportion of upper secondary level graduates, as well as increasing higher education enrolment (sub-system 7 - education),
- increasing importance of business services in economic activity (sub-system 5 – economic activities profile),
- higher GDP per capita (sub-system 8 – macro-economic and social performances).

b) This overall common evolution concerns :

- almost all the parameters of sub-system 1 (volume and funding of RD activities) and of sub-system 7 (education),
- one or two parameters of the profiles / specialisation sub-systems (scientific, technological and economic activities profiles) (sub-systems 2, 4 and 7),
- one parameter of sub-system 8 – macro-economic and social performances (higher GDP per capita).

These dynamics, which cuts across most of the sub-systems, can be summarised as reflecting the emergence of the knowledge based society.

3. On the whole, these common trends are neutral with respect to the divergence – convergence problematic

These common dynamics linked to the knowledge society develop in a parallel way and at a broadly similar speed among types. They do not result in either convergence or divergence, and they are somehow neutral in this respect.

4. The most important divergence element is related to the labour market and social protection sub-system and to the income equality problematic

Non-EU SSIP types evolve on the whole towards more income inequality, less social protection and less labour regulation, in sharp contrast with the evolution of EU-SSIP types.

This concerns most of the parameters of sub-system 6 (labour market and social protection), and one parameter of sub-system 8 – macro-economic and social performances (income distribution).

5. This divergence element, on the whole, strongly discriminates EU-Area SSIP types from the others

Such discrimination occurs in a double way:

- all EU-SSIP type share, on the whole, relatively high figures on the parameters related to the labour market and social protection sub-system and to the income equality problematic. Such parameters are one of the basis of the existence of what we have called a EU-Area SSIP broadly defined model (the other basis has to do with both the relative importance of industry as a whole, of certain mature sectors of industry in particular and their related innovation capabilities),
- it appears that precisely on those parameters, EU-types evolve in the same way, as opposed the the non-EU types. In other words, the dynamics at play tends to reinforce the specificity and reality of the EU-Area SSIP broadly defined model.

6. Important nuances must be brought to this picture

- There are questions on some aspects of the evolution of the EU-Mediterranean type, which has a questionable record regarding the labour market and social protection sub-system. At least an evolution which differs from other EU-types, and very much similar to the evolution of the Anglo-Saxon type.
- The EU-Nordic type exhibits some specific trends, mostly due to its performance in the electronic industry. There are hints that such performance has impacts on the SSIP and its dynamics. But on the whole, it is very much coherent with the EU-types dynamics.
- The position and dynamics of the UK raises questions: this country is clearly positioned in the Anglo-Saxon type and its dynamics is clearly coherent with that type, considered as non-EU, in other words diverging from EU-SSIP types.

F. Conclusions: how do social systems of innovation and production evolve ? What is the impact of economic integration and internationalisation ? What significance for the emergence of a European Research Area ?

1. The dynamics of the social systems of innovation and production: a mix of common trends and specific divergence aspects ; on the whole, no overall convergence among SSIP types

- A common trend among all social systems of innovation and production (SSIP) is move towards what can be called the knowledge society: the parameters concerned are the development of higher education enrolment, increased public and private RD and S&T activity, larger share of business services, biotechnology and ICT in economic activity. These parameters involve no significant phenomena of catch up, which make them neutral vis-à-vis the convergence – divergence problematic.
- Some parameters exhibit a divergent dynamics among SSIP types: such is the case of those related to social protection and labour regulation, as well as income distribution. These parameters result in increased EU-types similarity, but in overall divergence if one includes non-EU SSIP types. The hypothesis of ‘convergence clubs’ among SSIP types can be put forward.
- These findings tend to validate the hypothesis that:
  - a variety of institutional configurations governing technical change may exist, produced by history in a process that owes more to trial and error than to perfect rationality,
  - this particular type of path dependence questions the relevance of the idea that all countries converge towards the same technological (and institutional) model.

2. The relative performance of the SSIP types: diverging achievement on income distribution, but no systematic nor significant differences in achievement on productivity and employment

The question is to know whether or not in the 90s a shift occurred in the relative performance of these SSIP types. The hypothesis is that changes in the determinants of competitiveness as well as the development of

world wide markets and an extended internationalisation of production processes could well have eroded the links of SSIPs with performance.

Our findings lead us to differentiate among the various aspects of the performance of a SSIP.

Regarding the equity aspect (income distribution evolution), SSIP types have clearly differing achievements, i.e. the EU-types perform systematically better.

Regarding achievement in productivity and employment, no systematic nor significant differences among SSIP types have been found.

3. There are good reasons to consider there exist a EU-Area SSIP model: on the whole, EU-SSIP types have similar socio-institutional context of social protection and labour sub-system, as well as mature industrial sectors capabilities.

- There are wide EU SSIP types differences in terms of absolute level of activity and specialisation on many parameters. But the EU SSIP types have several key-features in common, which make them different. We call EU-Area SSIP model this broadly defined set of types, considered as variants of the model.
- EU SSIP types also have similar dynamics, which tends to validate the notion of the EU-Area SSIP model: same trend towards the knowledge society (common to all SSIP types), same reinforcement of their key features, in particular social protection and labour sub-system (specific to the EU SSIP types).

4. The role of EU integration in the dynamics of the EU SSIP types: process which is helpful – sometimes crucial - for member states to catch the world-wide common trends (knowledge society) and to develop EU specific trends (social protection and labour regulations)

EU integration is, in our view, a major factor for such parallelism both regarding entrance in knowledge society and the institutional context, in particular regarding social protection and labour regulations.

Our point is not that without European integration EU SSIP types would have necessarily diverged. We simply suggest that EU integration is a process which is helpful – sometimes crucial - for member states to catch the world-wide common trends (knowledge society) and to develop EU specific trends (social protection and labour regulations).

5. The building of a European Research Area: dealing with world wide trends, EU-Area SSIP model specificities and the EU SSIP types diversity

- First, the European research area must be in coherence with world wide trends in terms of the advent of a knowledge society, which means an increase in the volume of a number of activities (S&T, RD, higher education ...),
- Second, the European research area must take into account and build on the features of the EU-Area SSIP model: such features are shared by EU member states, but are specific to them. They constitute both constraints and opportunities which are at the root of EU specific comparative advantages in world competition. The socially protective labour regulations specificities can represent advantages in terms of attractiveness and know-how accumulation both in the public and private research and innovation sectors ; income equality is the basis for large demand of high quality goods and services, as well as a potential for skilled labour. We suggest the present challenge is largely to characterise better what could be considered as a European social system of innovation and production and its implications for the European research area in terms of building comparative advantages out of those specificities (at world level), which we share (at EU level),
- Third, the European research area must deal with the diversity of the SSIP of the EU member states. There are two kinds of diversity to be considered:
  - the diversity among variants of the EU Area SSIP model, which are basically differences in degree of development, or differences due to size of country or geography ; such is the case of almost all EU members,
  - the diversity among SSIP models within the EU, which so far concerns only the United-Kingdom. This relates to differences in essence and fundamental functioning principles of the SSIP.

The diversity in degree can simply be dealt with through market-regulated complementarities among systems having roughly the same procedures, references and logic. Integration can largely be an autonomous dynamics.

The diversity in essence cannot be integrated in a common 'area' through automatic – decentralised mechanisms such as the market. Specific compromises of institutional nature have to be negotiated and implemented so as to ensure internal coherence and intelligibility to the system. Of course, this may be painful and difficult, but the potential benefits are high, since it would give the EU a strategic advantage of being able to play the competitive game in a variety of settings.

The diversity problematic should lead to special attention to the EU-Mediterranean, to the EU-Nordic and to the UK SSIP types. For various reasons, they all represent high potential, and possibly high risk, assets for the EU as a whole.

### 3.2.2. TIK results and scientific activities

#### A. Technological Progress, Structural Change and Productivity Growth: A Comparative Study (Jan Fagerberg and Tao Zhang)

The objective of this sub-project was to analyse in depth some of the challenges arising for Europe from developments elsewhere, the evolution of Asian economies in particular.

#### **Methodology.**

The sub-project focuses on the relationship between specialization, structural change and productivity growth in manufacturing in recent decades. The perspective is similar to that of Salter (1960) in the sense that we analyze the manufacturing sector as composed of a number of different industries. However, we share with Denison (Denison 1967, Chung and Denison 1976) the comparative approach to studies of economic growth: the present sample includes 39 market economies (on different levels of development) between 1973 and 1990, basically all countries within this category for which data are available.

The sub-project's findings were collected in the paper: Fagerberg, Jan: "Technological Progress, Structural Change and Productivity Growth: A Comparative Study ", paper presented at *Economic Dynamics and Structural Change Workshop*, Eindhoven, October 3-4, 1999 (revised version forthcoming in *Structural Change and Economic Dynamics*).

#### **Scientific Findings.**

The results indicate that structural change still matters, but in a different way than before. The main difference concerns the role played by new technologies in generating structural change. In the first half of the 20th century, growth of output, productivity and employment were strongly correlated. Employment in industries based on new technologies (such as electricity and synthetic materials) expanded rapidly at the expense of more traditional industries, implying an important role for structural change in explaining overall productivity growth. More recently this relationship between output, productivity and employment has become more blurred. New technology, in this case the electronics revolution, has expanded productivity at a very rapid rate, particularly in the electrical machinery industry, but without a similarly large increase in the share of that industry in total employment. In fact, the industries that increased their role in total employment most substantially were generally traditional industries – mostly geared towards private consumption - with average to low productivity growth. Hence, in recent decades, new technology has not been linked with structural changes in demand, output and employment in the same way as before. This explains why structural change - in a pure accounting sense - was more important for productivity growth previously than it appears to have been more recently (at least up to 1990).

However, this does not mean that the electronics revolution - or the structural changes associated with it - have not been important for overall productivity growth in the period under study. First, the electrical machinery industry (which is the industry most intimately related to the electronics revolution) has experienced much higher productivity growth than any other industry, implying a growth bonus for countries with a superior performance in this industry. Second, there have been important spillovers to productivity growth in other industries, and available research indicates that these have been stronger at the local or national level than globally. Hence, the results presented in this paper suggest that countries that during the period under study here managed to establish themselves firmly in the electronics industry got a sizeable growth bonus from these investments.

#### **Policy Implications.**

It seems appropriate to issue a warning regarding the possible implications of these findings. First, leading technologies – and the industries most affected - change through time, and so do the conditions for

entry and the rewards from it. Thus, the relevant policy conclusion to draw from this is not that every country should move into production of electronics as fast as possible. Rather, the lesson is that there may be important potential gains to overall growth and – possibly – welfare from successful entry in technologically progressive industries that should be taken into account when designing policy. Second, little is said here about what the conditions for such entry were during the period under study or – of even greater importance for policy – are likely to be in the future. Without a clear understanding of these conditions – and how they relate to existing national assets and capabilities – it becomes difficult to discuss policy in a meaningful way. Arguably, these questions deserve a high rank on the future research agenda in this area.

#### B. Japanese policy initiatives at the national and corporate levels (Terje Grønning)

The objective of this sub-project was to contribute to the analysis of some of the challenges arising for Europe from developments elsewhere by way of placing particular attention on selected aspects of the evolution of the Japanese economy. In concrete terms this meant to gain increased understanding of (a) policy initiatives at the national and corporate levels and (b) R&D/innovation activities as they are undertaken by selected Japanese firms.

This sub-project encountered significant difficulties in its progress. As explained in the section on methodology below the difficulties concerned part (a) of the project, the study of policy initiatives at the national and corporate levels. One of the chosen policy initiatives was on national level, the MITI-sponsored *The Innovation Study Group* and its recommendations, whereas the other was on corporate/industry level, the Japan Employers' Federation Committee on the desired direction of the Japanese employment system. At the time of this sub-project's end, however, the final report of the former national level initiative had not yet been made public. Moreover, a relevant MITI official was not available for interview. These methodological difficulties lead to the abortion of this part of the sub-project. This resulted in only the partial fulfilment of the objectives outlined above and the transfer of the majority of the resources to part (b), which was re-established as a separate sub-project (see Sub-project: "Multinational R&D, Corporate Organisation and Innovations Systems" under workpackage C).

#### **Methodology.**

The chosen methodological approach was discourse analysis applied to policy initiatives, supplemented with a survey of the wider context and aftermath of each of the policy initiatives. We constructed for analytical purposes an ideal type of the institutions and the institutional elements of what has been understood as constituting the Japanese employment system thus far, and subsequently assess the Federation's policy in relation to this ideal type in order to investigate the degree of continuity versus advocated change. The findings of the finalised part of the sub-project were collected in the paper:

- Terje Grønning (1998). "Whither the Japanese Employment System? The Position of the Japan Employers' Federation", *Industrial Relations Journal*, Vol. 29, No. 4 (December, 1998).

#### **Scientific Findings.**

Recent studies collecting and assessing Japanese empirical data have stressed that there is a strong degree of continuity in spite of a radically changed business environment. Compared to this stress on continuity, the policy initiative under scrutiny is in overall advocating a break regarding a number of the institutions. Most notably this concerns the rearrangement of the labour market at large into three segments, as compared to the two segments of the current labour market. These radical recommendations have, however, hitherto been met with resistance from a number of other social actors, including labour and leading academics.

#### **Policy Implications**

Firstly the study reveals that there is a fair amount of disagreement amongst Japanese actors when it comes to the appropriate road of de-institutionalization of existing key institutions and eventual institutionalization of new institutions. If there ever was a "Japan model" which Europe related to it is not at all settled exactly what elements this model consists of at the moment. Secondly, within the general aim of understanding the nature and functioning of key institutions in a society the study serves as a lesson showing that even consistent pressure from an extremely powerful social actor (such as the Japanese Employer's Federation) will not result in the immediate change of a society's key institutions. De-institutionalization does not occur in a unilateral way.

### c. Multinational R&D, Corporate Organisation and Innovations Systems: A Study of the Domestic and European R&D-activities of the Japanese Speciality Chemicals Industry (Terje Grønning).

The objective of this sub-project was to contribute to the analysis of some of the challenges arising for Europe from developments elsewhere by way of placing particular attention on selected aspects of the evolution of the Japanese economy. In concrete terms this meant to gain increased understanding of R&D/innovation activities as they are undertaken by selected Japanese firms.

The sub-project has not encountered significant difficulties in its progress as such, but has undergone a re-organization of its position within the project by way of being re-allocated to Workpackage C from its original position in Workpackage B.

#### **Methodology.**

The sub-project focuses on a specific aspect of dynamics, i.e. the way a certain type of actors may or may not be influencing the evolution of particular innovation systems. There is wide agreement that the elements of an innovation system are, firstly, institutions (regulations which firms etc. have to take into consideration in their behaviour), and, secondly, organisations (firms, government agencies etc.) (Edquist, 1997). But relatively few studies have focused on the way particular organisations may influence and even contribute to the creation, maintenance and change of the institutions relevant for particular innovation systems. Establishment overseas by multinational enterprises (MNEs) was subsequently studied from this perspective:

- where R&D is being conducted (in what country or region),
- what kind of R&D is being conducted in Europe (as relative to in Japan and in the US) in terms of local added value,
- how the research is being conducted in terms of organisational form, and, in overall,
- why a corporation pursues a particular strategy.

The study proceeds by synthesizing three different types of approaches: firstly, the frameworks developed within international business studies regarding the notion of centripetal versus centrifugal forces which may influence the decision to locate R&D in a particular location (Bartlett & Ghosal, 1990), secondly frameworks developed within sociology, economics and organisation studies regarding institutions and institutionalization processes (Westney, 1999), and thirdly approaches regarding the make-up of different types of innovation systems (Lundvall, 1992).

Empirically, the issues of where R&D is being conducted and what kinds of R&D is being conducted are to a large extent being pursued at an industry level, whereas the issues of why a corporation pursues a particular strategy are treated by way of in-depth case studies of six corporations. The sub-project's findings were collected in the research report:

- Terje Grønning: *Multinational R&D, Corporate Organisation and Innovations Systems: A Study of the Domestic and European R&D-activities of the Japanese Speciality Chemicals Industry*. Report to the European Commission's Targeted Socio-economic Research (TSER) programme under the IVth Framework programme.

#### **Scientific Findings.**

Although the study is not able to answer directly any questions regarding specific causalities regarding the relationship between MNE-activity and particular innovation systems' dynamics, it does, however, illuminate the mechanisms behind a transition from a domestically based state of affairs to a state where the enterprise conducts its R&D (including high-value added R&D) on a multinational basis, and hence relates to several innovations systems simultaneously, including the domestic one. Within the two sectors studied the first overseas establishment was in 1985, there were still hardly any facilities abroad at all a decade ago, whereas there are currently more than thirty. This development has occurred during the same period that the Japanese economy has struggled with difficulties. Here we review the findings in terms of reasons for establishing the overseas units in the first place and the countries where they are located.

Several of the cases presented in this study are of a type where there are qualitative motives behind the establishment of these facilities. Firstly, the existence of an attractive *science and technology infrastructure* as well as access to *highly qualified human resources* is listed as a crucial factor behind the decision of establishing a unit in Europe in the first place. This is in particular true for the basic research units, but is also mentioned as an important factor for clinical development units. Secondly, *product market related factors* are especially important for some of the corporations. First and foremost these are the printing inks corporations. They stress that printing inks are local products and that it is essential to have a presence in the regions where they aspire to market their products. In addition two pharmaceutical corporations which started out with (and

still have) only a clinical development unit present in terms of R&D in Europe used this as an opportunity to become acquainted with the European market. These units also cite the *availability of suppliers* (CROs) as another positive impact. Finally one could mention that the factor concerning *government regulations or subsidies* was not mentioned as relevant for any of the case study corporations' units.

The enterprises which were studied have a preference for particular countries and regions. There are as many facilities in Europe as there are in the US, but there is a majority of basic research units located in the US when in seen in comparison to Europe. Within Europe there are two printing inks and four pharmaceutical laboratories located in Germany, whereas there are no printing inks and ten pharmaceutical laboratories located in the UK. The only other countries which is represented are the Netherlands and France, with respectively one pharmaceutical facility and one printing inks European headquarters and manufacturing facility which includes some research and development.

### **Policy Implications**

The findings suggest a number of implications for European policy both at national and European levels. However, most of these issues are difficult to pose in the form of concrete recommendations since this has been predominantly a studies according to qualitative methods, and we will here pose the issues as a series of hypotheses instead.

Firstly, the aspects studied in connection with the motives of the enterprises provide certain policy related lessons. We have shown that these enterprises came looking for, first of all, science and technology infrastructure appropriate to their industry, and, secondly, for an entry method to the European market. These assets were, however, not made available to them as a result of conscious policies. Rather there seem to have been policies directed at the strengthening of regional and national infrastructures within specific sciences and technologies not particularly targeted at MNEs, but this did in turn contribute to attracting the foreign corporation's R&D unit. A lesson for future policy measures could thus be to indeed make sure that particular strength areas are indeed made more visible to MNEs, if one is of the opinion that the R&D activities of MNEs should be attracted to the area.

Secondly, the same issue can be broken down to a country by country question. Looking at the pharmaceutical corporations alone the list of overseas wholly-owned sites shows that there are basically three different overall strategies. The first is a limited internationalisation constricted to selective establishment of clinical testing laboratories, the second a selective establishment of basic research laboratories, and the third a combination of establishing both clinical testing and basic research laboratories overseas. As for regional distribution there is a virtual "draw" in terms of number of sites in the US and in Europe, but it is, however, significant that there is a slight emphasis regarding the location of basic research institutes to the US rather than to Europe. This phenomenon is mainly due to the perceived or actual strength of US research in biotechnology. As for the activities in Europe seen in isolation the concentration on the UK and on Germany stands out. We have seen that it is predominantly the perception of superior science and technology infrastructure which makes the United Kingdom and Germany so attractive to the enterprises. Is it possible for other European countries to emulate the German and British success in this regard? Or, as seen from an European level, would it not be better to avoid policies targeted at such emulation exercises and rather stimulate diversity, which in turn may stimulate extra-European investments within R&D within other industries elsewhere in Europe?

Lastly we may turn to the issue of organisational modes and the policy implications of transition of one organisational mode to another. Bartlett and Goshal (1990) did at the outset formulate their ideal types as value free as seen from the perspective of researchers.

In other words, it was entirely circumstantial and not an absolute and evolutionary dependent issue of one form, for example the integrated network mode, being superior to, for example the centralised hub mode. Indeed there are still differences, such as the ones shown within this study, which may be due to the strategic options chosen by the enterprises, resulting in a more or less conscious choice of a centralised hub or centralised network mode of operation even in the context of a globalising economy. However the existence of integrated networks aimed at global-for-global processes imply that science and technology policy ought to accommodate for such cases. In other words, in the extent that institutions and policies were perceived of as being territorially bound in the sense of being targeted at particular regional or national levels, the flow of knowledge becomes more complex with the advent of integrated networks and may subsequently necessitate policies which accommodate for these complex flows.

### 3.3. Specific crossed perspectives on systems of innovations: the regional and multinational firm levels (Work Package C)

#### 3.3.1. ROTTERDAM SCHOOL OF MANAGEMENT research and results on multinationals and systems of innovation: towards an international interactive perspective

##### A. Introduction: interaction in innovation as an international race

Innovation has become an increasingly international and interactive process. Interaction can thereby take many forms:

- Interaction between teams/persons within the same company;
- ‘extra-mural’ interaction of company R&D laboratories and networks/clusters of other firms and actors;
- interaction between countries and their governments in the formulation and implementation of innovation policies;
- interaction between internationally operating firms that decide upon the spread or concentration of their innovation activities;
- interaction between governments and firms.

The international interaction over innovation (in) between governments and firms has clearly intensified over the 1990s, emanating in a true international race for higher R&D expenditures. In the 1981-1998 period the total Gross Expenditures on Research and Development in the OECD region (in current PPP) more than trebled from 156 billion U\$ to 518 billion U\$ (OECD databank). As a percentage of GDP in the OECD region R&D expenditures increased in the 1980s from 1.99 in 1981 to reach a temporary high of 2.35% in 1990. Over the 1990s, the share of R&D expenditures in total GDP stabilized at around 2.2-2.3 percent.

On the surface the international innovation race therefore does not seem to have intensified. But in the 1990s, the shift of the actors in the race has been from governments to firms. How many actors are important in shaping the international interaction? Are we talking in a game-theoretical perspective of a multiple-actor game or one in which there are only a limited number of players (a “small numbers” game).

##### B. Leading research questions

Integrating the strategic perspective of multinational corporations and their R&D strategies with the perspective of (national) systems of innovation is a new endeavour. This study therefore provides a first attempt in tackling the relevant questions. Leading questions that guided the research project have been:

- Does the National Systems of Innovation literature take into account the strategies of leading companies? In addition: does the NSI literature take into account the international dimension in general and the strategies of multinational companies in specific? Does it make a difference whether NSIs are ‘closed’ or ‘open’ and include ‘home’ or ‘host’ companies?
- Can the NSI framework be conceptually and politically expanded to include the multinational perspective or is a completely different framework required?
- What relevant trends can be observed in the strategies of leading companies: centralisation, decentralisation of R&D or something else; do national origins of firms still matter?
- What are the consequences of the interaction of governments and of leading corporations (that are partly international) for the effectiveness of policy making.

The study is intended to cover the dynamic interaction between (national) systems of innovation and multinational firms, which is graphically illustrated by exhibit 1:

**Tableau Exhibit 2 MNEs interacting with home and host countries**

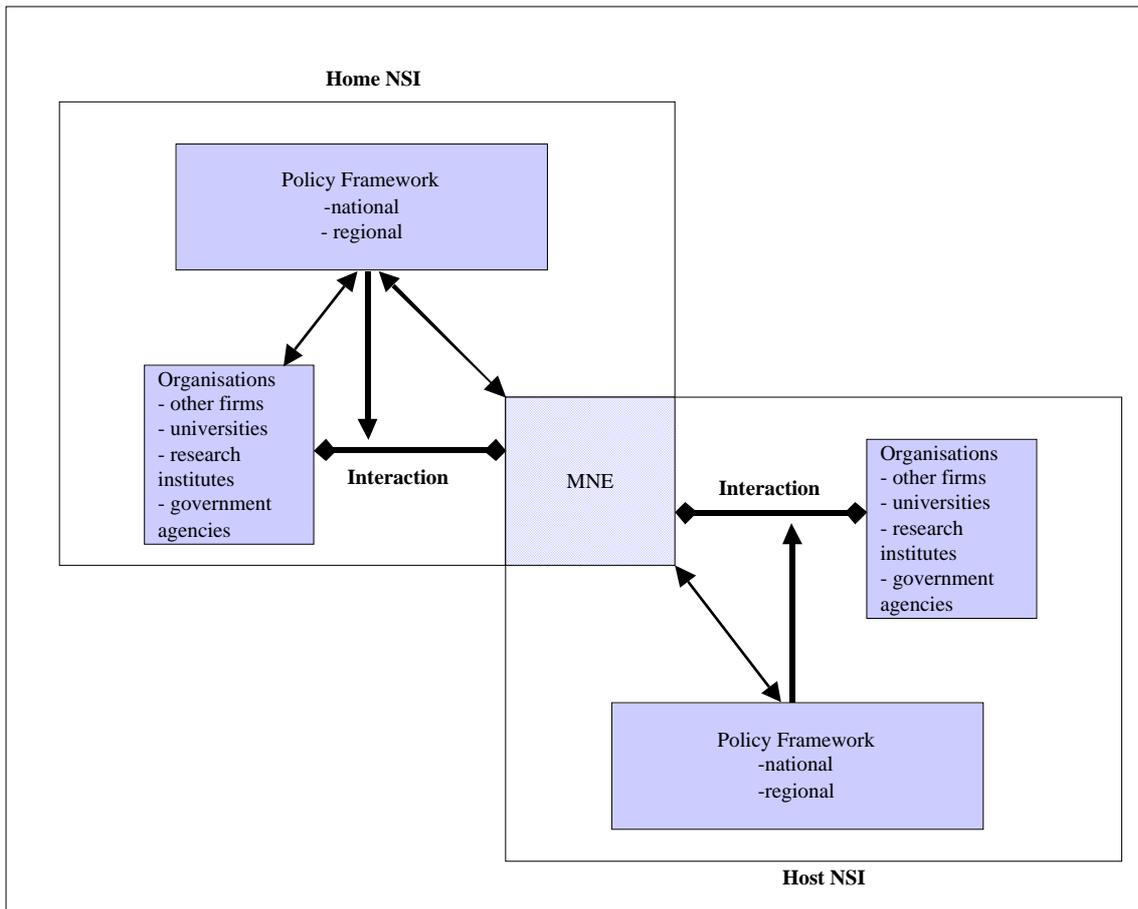


Exhibit 1 is a simplified figure. In the presentation of exhibit 1, a single Multinational Enterprise (MNE) is the focal actor, whereas the National Systems of Innovation are categorized as 'home' or 'host'. The prime unit of analysis is the multinational corporation. UNCTAD (1999) studies reveal that at the moment around 50.000 multinationals exist (from an assessed 7.000 in 1970) coordinating more than 300.000 subsidiaries around the world. So each MNE coordinates a number of activities over host and home countries. Their strategies are based upon an internal dynamism, but also on a competitive logic in which they respond to the actions of other firms. The focus of the analysis can also change, by choosing a national focus. This analytical angle will also be used, in which case the relevant distinction becomes between 'home firms' and 'host firms'. In addition exhibit 2 also refers to two countries that interact through the multinational enterprise. Countries and governments, also interact directly with each other, independent of the MNE.

The task to cover the international interactive dynamics of innovation is a complex one. The concepts to cover these processes are not yet well established, whereas research methods are in their infancy. The research project therefore is still relatively exploratory, but nevertheless aims at coming to relevant policy conclusions. An alternative approach would have been to do an in-depth study of either one system of innovation or of a limited number of multinationals

In order to cover the dynamism at least seven different techniques have been eclectically used for various parts of the analysis:

1. *Exentensive literature search*: what is known about the R&D and innovation strategies of multinational firms and what do we already know about the interaction between (national/sectoral/regional) systems of innovation and multinationals? The literature search has been a vital part of the research project, in particular for the interaction between multinationals and systems of innovation, which has been covered only scarcely and rather scattered over the literature. By bringing the literature on this topic together, the

approach makes it possible to come to a more sound analytical and conceptual framework in the other parts of the study.

2. *Firm R&D strategy search*: The Erasmus University is developing a databank on the internationalization strategies of so called “core companies”. A core company is a leading and sizable actor in national business networks (Cf. Van Tulder, Van den Berghe, 1998). A core companies’ leading position can be derived from R&D competencies (as will be illustrated) but not always. Data on the so-called CORE 200 firms were complemented with R&D information through an extensive search in annual reports, available databanks and the like (see Annex B). In addition a lists of the biggest R&D spenders in the world and for a number of national innovation systems under consideration, was composed. This resulted in identifying the TOP5/10 R&D actors in a number of countries and to the TOP50 R&D spenders in the world. It will be researched to what extent the CORE list – in which firms derive their importance from their market size – and the R&D listings – in which firms derive their importance from their R&D budgets – overlap.
3. *International patenting statistics*. Some of the data collected under 2 were linked to the OST data on patenting at the European Patent Office. Particularly interesting has been the spread of patenting registration over a number of subsidiaries (countries) for the sample firms from the CORE200 and the TOPR&D listings.
4. *International Strategic alliances*. An important element of the internationalization strategy of firms – in particular in technology areas – are strategic alliances. This part of the approach can be developed much further, but for the moment the research has tried to couple the information as contained in the MERIT/CATI databank on strategic alliances (Cf. Hagedoorn) with the CORE200 sample of firms.
5. *Questionnaire*: a selection of representative multinational firms in the three leading R&D sectors – cars, electronics and pharmaceuticals - were send questionnaires to cover for their internationalization and R&D strategy, and the degree to which they were making use of R&D outsourcing (see Annex A). This questionnaire contained a relatively small number of questions, in order to trigger the desired answers. Around twenty of the leading firms in the area responded.
6. *Interviews*: in order to get to grips with the dynamism of the interaction between multinationals and governments in particular, around ten face-to-face interviews were held. The companies selected for these interviews were taken from the three European countries selected for further research and which have sizable home multinationals: the UK, the Netherlands and Germany. These interviews were conducted on the basis of a semi-structured questionnaire. Interview protocols were drawn up. The interview results are elaborated in a running analysis without exact reference to the sources (for source protection). (See Annex C).
7. *CIS questionnaire*. For the final part of the study, the more detailed case study of the Netherlands, the 1996 Community Innovation Survey (CIS) results were used. The 1996 survey is the last available survey. The 1998 survey will only be available at the end of the year 2000. CIS collects data on innovation strategies of firms at the level of plants (legal entities registered in the country as ‘firms’) performing homogeneous market oriented production processes. In collaboration with Statistics Netherlands a methodology has been developed to reconfigure and consolidate the data (10,000 records to be precise) on plant level to data per core company. This enabled to link the accumulated survey results to the largest home and host companies represented in the Netherlands. The group of fifty largest home companies includes a number of firms that are only slightly international, but in Dutch circumstances all firms are in principle international. The group of 100 largest host firms are by definition multinational. These two groupings of firms represent the bulk of innovation activities in the countries. For further details of the methodology see Goedegebuure (2000).

#### **What the research did not achieve.**

This research effort has accumulated a substantial amount of new data, which in the context of the CDIS project could only be partly analyzed. It could hardly build on a well-established research tradition. For that reason the results are intermediary, whereas in the research methodology an eclectic use has been made of a variety of techniques. The techniques are applied to varying groupings of firms that sometimes overlap. This is by intend. It implies that the empirical findings in particular in the second part of the study are rich, but as yet difficult to analyze to their full extent. Where possible links were established with other data collections, but this has been complex and full of empirical problems. Many of these problems have been solved, but many more can still influence correct further interpretations. Where appropriate this has been included in the observations. The search process supported the relevance of the original question on the interaction between NSIs through Multinational Enterprises, the importance of the distinction between home and host companies (and NSIs), the importance for international innovation of a limited number of core companies. A first policy

agenda is formulated on the basis of these observations for a number of countries – the aim of this research project. As to the exact interaction between multinationals and NSIs, however, this research project has only started to make first observations. From a holistic perspective in some of the most relevant areas (firm strategies, recipient end of innovation systems) more specific observations have been made, but there is clearly a lot more to be said and researched about the topic.

### C. Part One

#### **International/interactive innovation.**

Chapter one points out that a notable deficit of the NSI approach is its lack of explicit distinction between various types of firms in general and MNEs in particular. The NSI literature distinguishes various types of *organisations* such as firms, universities, research institutes, and government agencies. This is inherent to the notion of innovation as an interactive process. Yet, the level of analysis is too aggregate to segment different types of firms. Consequently, the NSI literature has little to say about how MNEs affect the performance of NSIs. Only Chesnais (1992) has attempted to deal with MNEs in NSIs. Chesnais aims to discuss the possible impact of foreign direct investment (FDI) on the structure and the organisation of NSIs. However, Chesnais does not identify exactly *how* MNEs influence NSIs.

#### **NSI literature: hardly room for multinationals.**

While the impact of MNEs on NSI is starting to be debated, its counterpart, i.e. the possible influence of a multinational's NSI on its R&D strategies, has deserved little attention. Studies (e.g. Patel and Pavitt, 1991) often only go as far as to provide evidence of the fundamental importance of the home NSI for the technological activities of MNEs. Only Kuemmerle (1999) deals explicitly with the impact of a NSI on the R&D strategies of its MNEs.<sup>5</sup> Moreover, the literature often suffers from a methodological bias, as many studies do not make a distinction between home-based MNEs and foreign MNEs in a country. Consequently, studies that claim to give evidence on MNEs from a particular country, without distinguishing national firms from affiliates of foreign firms, in fact fail to do so. This study will contribute to this area.

The literature on national systems of innovation as discussed in chapter two offers the fundamental concepts for our analysis. The principal idea underlying the NSI approach is that innovation almost never occurs in isolation (see for example Rothwell, 1977; Pasinetti, 1981; Freeman, 1987; Von Hippel, 1988; Lundvall, 1992b; Freeman, 1995; Edquist, 1997a; OECD, 1998). Instead, the pursuit of innovation involves the interaction between various organisations so as to gain, develop, and exchange various kinds of knowledge and other resources. Firms are important organisations in innovation.<sup>6</sup> Other organisations include universities, research institutes, investment banks, schools and government agencies. Innovation can thus be understood as an interactive and socially embedded process. Based on this notion, a country's system of innovation can then be defined as the complex of organisations contributing to innovation and the interactions between the various organisations. The actions and interactions of organisations with respect to innovation are governed by institutions (Lundvall, 1985, 1992b; Johnson, 1992; Edquist and Johnson, 1997; Leoncini, 1998). In this context, institutions are sets of common habits, routines, established practices, rules, laws, etc, regulating behaviour (Hall, 1996; Edquist and Johnson, 1997). We have argued in the previous chapter that for the purpose of taking further steps in the empirical research on national systems of innovation we need a stricter actor approach, thereby avoiding the difficult debate on institutions versus organisations.

#### **Diverging trends in international R&D organisation.**

Chapter three gives an overview of the literature on the internationalization of R&D. A number of trends were identified, that to a certain extent run contrary to each other:

- an increase in the number of R&D units abroad since the 1980s, albeit using different modes of establishment of R&D units;
- an increase in the degree to which such foreign R&D units are embedded in local NSIs;
- and more recently a trend back to a re-centralisation of R&D by some firms in the home NSI.

### D. Part Two

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<sup>5</sup> The author investigates whether countries from Japan, Europe and the U.S. have different propensities to conduct home-base augmenting versus home-base exploiting R&D abroad. The results indicate that there are no differences between firms from the three different regions.

<sup>6</sup> For an empirical confirmation of the significance of firms see e.g. Lankhuizen (forthcoming).

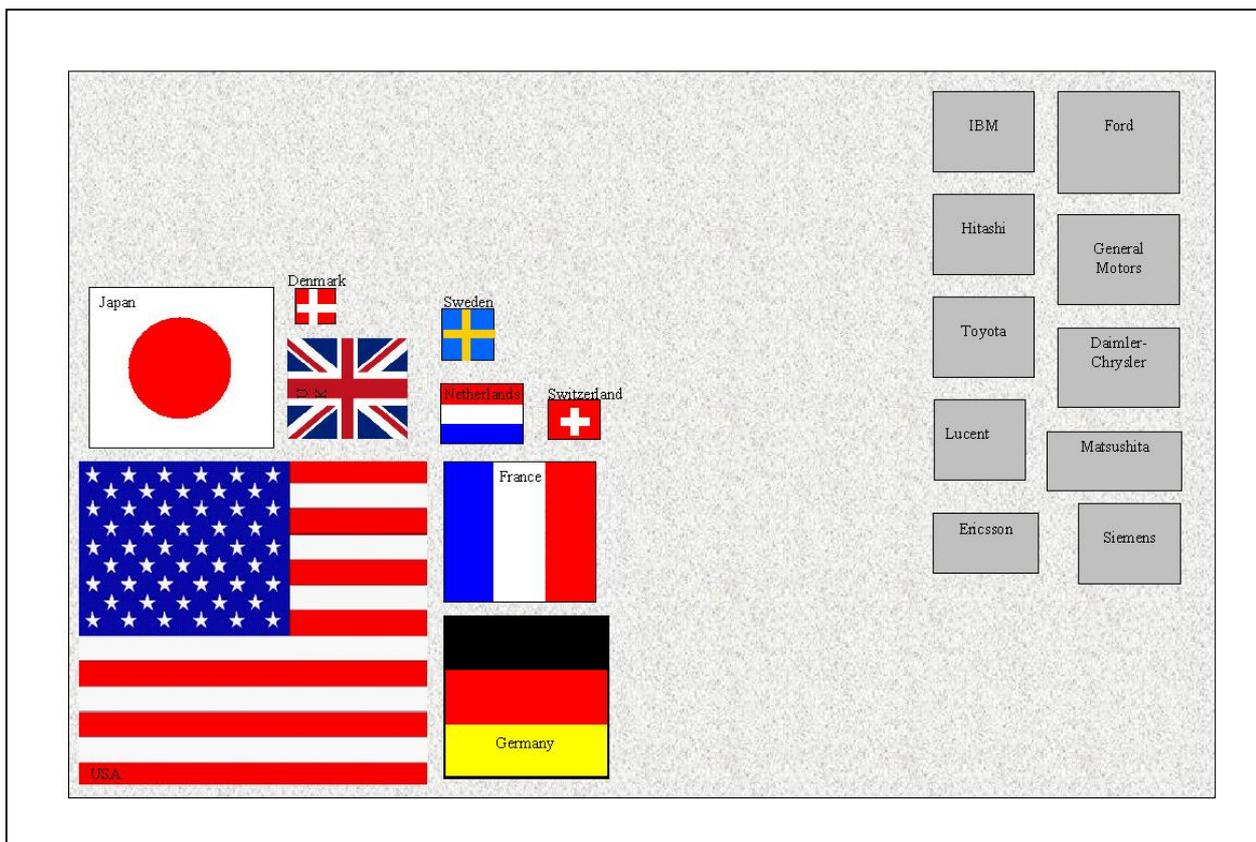
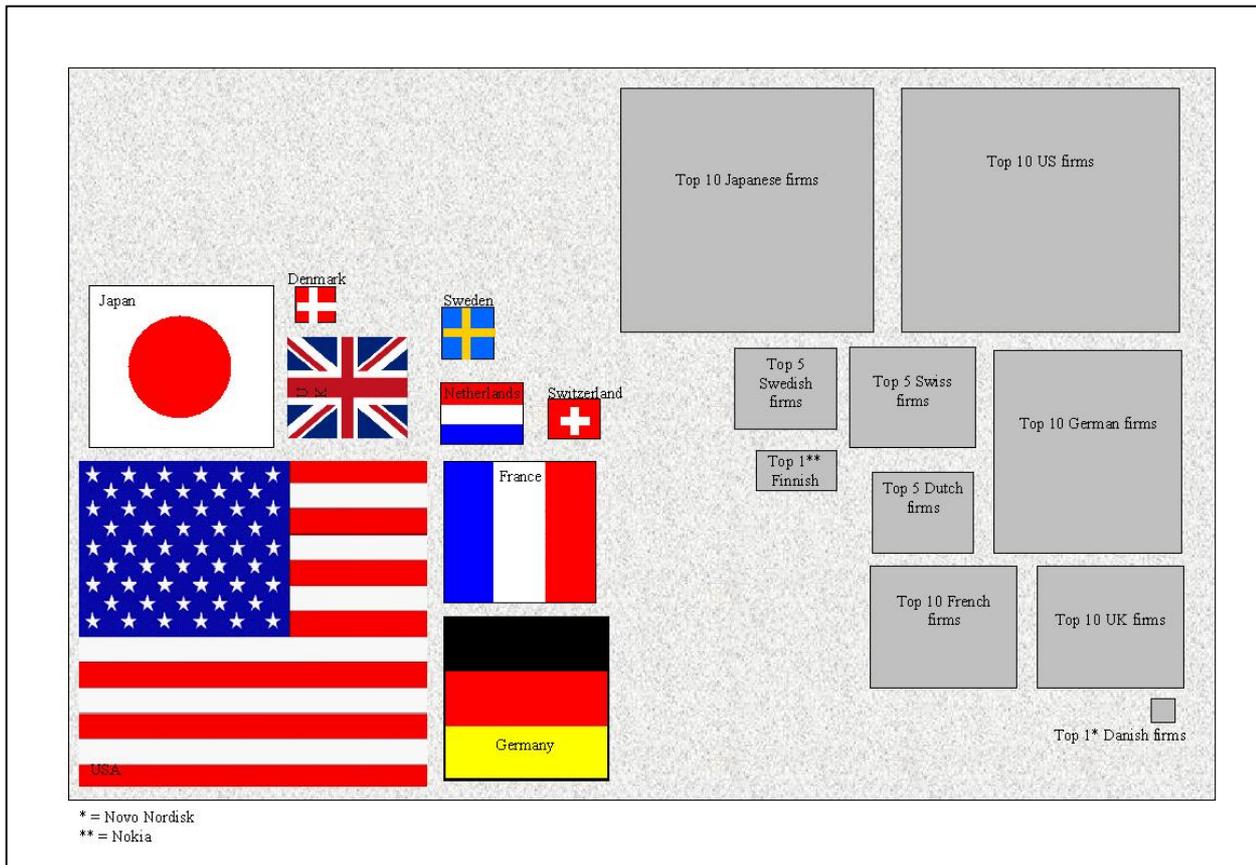
Four analytical ‘angles’ have been chosen, leading to different (but overlapping) sets of firms that are studied in part Two for their various types of interaction amongst themselves and with the (national) systems of innovations:

- *A worldwide sales perspective* in which the size of the sales and the relative size of firms is taken into account: this is the listing of 200 core firms taken from a large number of countries (almost all OECD).
- *A worldwide R&D perspective* in combination with a national perspective in which the absolute size of R&D expenditures is the selection criterion: this results in a listing of the TOP50 biggest R&D spenders in the world (chapter four) and also results in lists of the TOP5 or TOP10 biggest R&D spenders in important countries.
- *A worldwide sectoral perspective*: from the four most leading sectors in terms of innovation expenditures (cars, electronics and electrical equipment, pharmaceuticals and the chemical industry) thirty leading core firms were approached through a relatively simple survey. Sixteen responded with a relative good spread over the Triad
- An idealtype *country perspective*: in the three European countries selected (see chapter four for more details) that contained sizable ‘home’ multinationals – the Netherlands, Germany and the UK – a number of core R&D companies were approached for in-depth interviews in order to gain insight into the national dynamism of the interaction between the NSI and the core companies. Each of these three countries has a different attitude towards ‘home’ multinationals due to a different position of these firms in their NSI. For this research project nine companies were selected.

#### **The international R&D Arena.**

Chapter four: an overview of the various “arenas” actors perform in, leads to the conclusion that interactive innovation is basically a small numbers’ game. The OECD arena pictures this game neatly (Exhibit 2).

## Exhibit 2 The OECD R&D Arena, 1998/1999



On the basis of different dynamics between home and host multinational, five different 'ideal-type' European NSI were selected for further research: The UK, Germany, the Netherlands, Ireland and Denmark.

- One large country where impact of both home-based and host MNEs on the NSI is high. The choice made is the UK, which has a large number of R&D intensive multinationals as well as a high level of foreign investment from multinationals from the US and Japan.
- One large country where the impact of home-based MNEs is high but the influence of foreign MNEs is not so strong. Germany is the best example in Europe that fits this description with a number of strong national giants but relatively low level of foreign funding of R&D.
- One small country where the impact of home-based MNEs on R&D is high but that of foreign MNEs is not so strong. R&D expenditures in the Netherlands are highly dependent on five large manufacturing multinationals. At the same time the foreign investment in national R&D is not at a high level.
- One small country with a weak impact of home-based MNEs but very strong foreign influence. Ireland is characteristic in this respect since 68% of its manufacturing R&D comes from foreign companies, whereas it hardly has any indigenous companies with a substantial R&D effort.
- One small country with a weak impact of home-based MNEs as well as foreign MNEs. Denmark is representative for this case. It represents the antithesis for the previous typologies and their respective countries.

### **International R&D organisation: mixed trends.**

In chapter five, firm strategies are the central level of analysis. Therefore the relevant distinction becomes between ‘home’ and ‘host’ *countries*. The R&D, innovation and patenting strategies of different sets of leading/core companies are observed. Their strategies concerning the international organisation of the R&D and invention

Respondents in interviews (including the interviews held for this research project) generally bring forward that R&D is internationalising. On the basis of the evidence above this impression can not be unequivocally substantiated. There is no increase in international R&D expenditures for all firms, in all sectors and/or for all countries. Major differences between firms, sectors and countries remain. From the comparison between ‘total Tni’ and ‘R&D Tni’ a strong relationship could however be deduced: the internationalisation of R&D strongly correlates with the internationalisation of total corporate activities. The general feeling amongst respondents might be that the internationalisation of companies is increasing and thus – due to the above correlation – the internationalisation of R&D. For large parts of the first half of the 1990s, this was indeed true. UNCTAD’s World Investment Report (in collaboration with the Erasmus team) noted increasing levels of TNI in the first half of the 1990s. Paradoxically, the trend for the following years seems reversed. Since 1996, the most international firms (as measured by their internationalisation of assets) show a trend of a *declining* TNI (UNCTAD, 1999; 2000). This decline is partly due to the Asia crisis and a perceived increase in instability in the international financial system, and to the increased regional dynamism due to stepped regional integration processes. Would this process therefore also lead to a declining R&D TNI? It seems more probably that the decline in TNI will only after a time-lack be accompanied by a comparable decline in R&D Tni. But this recent development clearly deserves further research.

From the comparison between ‘total Nsi’ and ‘R&R Nsi’, it could also be deduced that R&D activities are far less internationalised than total corporate activities. Thus although for some MNEs, a large part of their R&D expenditures and R&D employment is located outside the home country, they still concentrate their foreign R&D activities in a few, relatively large foreign R&D laboratories. Although these conclusions do not confirm the notion that technology-oriented factors are becoming increasingly important, they certainly do not disprove it. It could be argued that MNEs only establish foreign R&D laboratories in those, relatively few, countries, which possess complementary sources of scientific and technological skills and knowledge. MNEs do not just ‘blindly’ follow the internationalisation of production when they want to decentralise their R&D, but, instead, they carefully select certain host countries with to gain access to the main centres of R&D excellence for their industry.

The evidence on the internationalisation strategies of firms remains mixed. Companies centralise as well as decentralise certain R&D-related activities. The more international companies are, the more they have also internationalised their R&D. But the countries over which they spread their innovation activities (including the sourcing of inventions) remains relatively limited and often restricted to *neighboring* countries. The number of international (European) patents has tremendously increased, which confirms in any case a trend toward a more regional innovation system. In documenting the international innovation strategies of

groupings of important multinationals and/or core companies, it is shown that the home-base still matters. Companies want to exert control over their innovation process, which amongst others resulted in a rather strong degree of control over the ownership of patents. National patterns were quite obvious illustrating the importance of national institutions for the functioning of the core players (and thus for the NSI). It is not sure that this will lead to the claimed increasing interdependence of R&D laboratories spread around the world (see chapter three). For the moment, the OECD countries prevail, whilst developing countries hardly play any role in the international innovation arena. Many core firms see a potential in some of the developing countries, which makes them (potential) candidates for location. In looking at national patterns, the United Kingdom reveals a rather exceptional view as regards the European R&D arena. This is another excellent reason to take the country as ideal-type examples for an NSI. If the national characteristics of core firms are more influential on the internationalisation of their R&D (or not), one can expect that the national bargaining arena remains more relevant than the international and sectoral bargaining arena.

#### **NSI-MNE interaction: home/host country matters.**

In chapter six, the national perspective becomes central for the analysis – consequently the relevant distinction is between ‘home’ and ‘host’ *firms*. The various manners in which specific MNEs interact with *specific* NSIs are analysed. NSIs differ from one country to the next. The way in which organisations involved in research and technological development – like universities, research institutes and firms – act and interact, differs between countries. Moreover, the way in which the S&T infrastructure interacts with public policy differs too. The role of MNEs differs from one country to another as well. As a result, the impact of R&D strategies of MNEs, in particular their internationalization strategies, will differ between countries. The typologies of NSIs that were developed in chapter four are tested in this chapter: the distinction between five countries sharing a different (idealtpe) relationship with home and host MNEs is relevant.

#### E. Part Three: policy conclusions of Rotterdam School of Management research

This study has established that multinational companies play a key role in national systems of innovation. Their share of total spending on R&D in most countries is so significant that a radical change of these companies’ strategies will be felt throughout the system. The intensity of their interaction with other parts of the system varies from country to country, but inter-firm relations as well as collaborations with the public research infrastructure is eminent. In this sense the actions of multinational should be a prime policy concern for both small and large countries.

The internationalisation process of multinationals and in particular of core companies that were bound to the national home market (for instance due to regulation) is progressing with leaps and bounces. The pace varies between sectors and sometimes firms even lower their internationalisation. Likewise, R&D gets re-centralised from time to time. In case this happens (for instance with Philips) firms tend to choose for the well-established and well-known home-base. Therefore **history matters**. MNEs value the networks, common culture, familiarity with labour practices, and linkages that have been created over the years in their home country.

As a consequence **nationality still matters**. Firm nationality - and thus the distinction between *home and host* system of innovation/country - still matters in at least three ways:

- In most countries the bulk of the R&D expenditures is still performed by national (home-based) firms. The UK seems to become an exception.
- The internationalisation patterns of innovation (in both patenting and R&D organisation) often reveal more distinct national than sectoral or size-specific characteristics. This corroborates the idea that the home-base influences the properties of the internationalisation strategies of MNEs in quite distinct manners (Cf. Whitley, van Tulder/Ruigrok). As a consequence, interactive innovation with a subsidiary of a Japanese, German or American company reveals also distinct characteristics. Patenting strategies for instance reveal varying degrees of centralisation and control. *National styles of multinational companies exist*.
- There are still clear differences in the R&D strategies (including R&D intensity and the nature of the R&D function) of ‘home’ and ‘host’ firms inside national innovation systems. An exception seems to be the Netherlands, where host multinationals seem to share comparable characteristics as most of the home multinationals.

Due to the latter observation, it is save to conclude that **ownership and thus the distinction between home and host company still matter**. As soon as an important national players get taken over by a foreign partner they become part of the strategic planning of exercises of other firms. This can increase the function and position of the local R&D department. But this only seems to happen in case the surrounding NSI is strong and dynamic (and therefore probably also contains a large number of other innovative players). In case the surrounding NSI is relatively weak the position of the R&D department of the acquired firm tends to become jeopardized. There is anecdotal evidence for this, but not yet systematic research.

#### **Size still matters.**

R&D is a small numbers' game, the dynamism of interactive innovation consequently often depends on the interaction of only few big players. Critical mass is important for firms to locate activities somewhere. Firms themselves require critical mass, partly also because governments have lowered their relative expenditures in R&D. Weakly developed NSIs therefore will never attract really high-end parts of the R&D organisation of host-based multinationals.

#### **International coordination is still largely lacking.**

International innovation systems are developing, thereby overarching national boundaries. But this process evolves at a relatively slow pace, due for instance to the limited progress in setting up really supra-national institutions:

- The multinational firm itself can be considered to be a supra-national innovation system (perhaps even an institution), coordinating innovation over a variety of countries and aimed at its own (supranational) business aims. But with strong ties to its home-base and therefore not really supra-national in nature.
- Slowly a system of world-wide patenting is developing in which on the basis of intellectual property right (WIPO) rules more and more firms are applying for harmonised patents. In practice, however, distinct patenting strategies can be observed, while at most the first steps towards a macro-regional dynamism (in Europe) in patenting can be witnessed.

The prevalence of national patterns, combined with the lack of real supra-national institution should make the fear of policy makers that their home-based firms could become completely 'footloose' not justified. Investments in R&D abroad are mostly additions to home-based R&D activities and not a replacement. Nevertheless, MNEs are very well aware of the political sensitivity of this issue and therefore cautious to reveal their long term plans for shifting the geographical focal points of their R&D activities.

#### **MNEs still value proximity in collaborating with other parts of the innovation system.**

The qualitative part of our study showed that MNEs value to work with research organisations in their region or in not too far distance from their headquarters. However there were some clear trends coming out this part of the research that might weaken this current approach in the future:

- The quality of research in the home country has to be high enough to at least keep up with international state-of-the art. Some concern was expressed relating to the deterioration of the science base and the lack of highly qualified staff to perform this.
- MNEs are finding their ways to research excellence regardless where in the world. Although the headquarters of corporate research are not being relocated, specialised research centres in particular technologies are established in those areas that can offer the skills and knowledge. Examples are the US West Coast, areas in South-East Asia (Taiwan, Singapore, China), India for information technology. MNEs in the more mature sectors such as chemicals and automotive will be less prone to these global shifts since the core technologies have already settled in specific areas. Particularly in the newer technology areas, the regional specialisation patterns are still moving and therefore R&D strategists with MNEs will keep an open mind to where to locate specialised research units.
- MNEs stated that their collaboration with the public research infrastructure is oriented more towards fundamental-strategic research than towards applied problem solving research. Applied research, particularly when it is closely connected to the companies' core business is done in-house and not shared with external parties. It is in fundamental research where MNEs seek complementary expertise, particularly to stay informed about a range of technological options for the future. On the other hand we see a trend in Europe that universities are encouraged to move towards more applied and market – near research and to play a more active role in helping industry to innovate. From the perspective of MNEs this trend would make the public infrastructure less interesting since the complementarity with their own knowledge base is diminishing. The policy conclusion is that in order to embed MNEs in

the national system of innovation, investments in basic research are an indispensable element of a healthy system. This does not imply a move back towards mono-disciplinary, blue sky research, but interdisciplinary fundamental research that fits the 'Mode II' model.

- The main bottleneck from the perspective of MNEs, is the cultural gap between the universities and the logic of their business enterprise. Particularly in Germany, and to a lesser extent in the Netherlands and UK managers of MNEs perceive the universities as organisations that stand too far away from the needs of commercial enterprises. There is still a reluctance to perform research with a commercial focus, the bureaucratic regulations do not allow an efficient collaboration and often senior staff are not willing or allowed to collaborate in projects. From the perspectives of multinationals the research-industry interfaces are not functioning well enough, despite many policy attempts to improve this relationship. This calls for a re-orientation of present policy efforts on industry-research interfaces. We have to note that policy should address a wider industrial community, than the MNEs alone. Different target groups from the business sector will need different interfaces.

In deciding where to make R&D related investments MNEs are predominantly following the overall company strategy where general conditions for competition and innovation (tax, labour markets, government regulations) and proximity of markets are prevailing over the presence of specified knowledge. In many cases R&D settlements follow the location of manufacturing sites. Nevertheless given the fact that some MNEs are clearly moving towards decentralisation of the R&D functions within the corporation, there is more room for specialised R&D labs in areas that have proven to provide knowledge excellence and skills in given technologies. **This would support the European policy approach to promote 'centres of excellence' that have a clear international profile as world leading in their area of science.** Having acknowledged centres of excellence would attract and embed R&D investments not only from European MNEs but world wide.

**An important partner in outsourcing R&D, in particular pre-competitive R&D appeared to be the high-technology start-up companies.** In comparison with the more formal public research infrastructures these are highly specialised and commercially oriented organisations that provide knowledge near to the core areas of the MNEs. Having a large pool of these high-tech start-ups in a national system of innovation would make its fabric more attractive for R&D investments by MNEs. The policy implication is that the promotion of leading edge start-ups would add to the attractiveness of a national system of innovation. Germany has been very active in supporting this business start ups and new regional technology networks are arising from business ventures in areas such as nano-technology, information technology and bio-technology. In the UK this area has been picked up by commercial venture capital initiatives and entrepreneurial universities. The Netherlands and Ireland are late comers to this area and are only just launching initiatives in some technology areas.

**Having a highly qualified workforce relevant for their most strategic functions (R&D, marketing, finance) is the key asset for MNEs.** This means that good universities are an important recruitment pool for skilled staff and particularly research personnel. The education function of universities are often as important as their research capabilities. There was concern in some countries (Netherlands, Ireland) that the quantity of graduates is not sufficient to satisfy skills requirements in those countries particularly in the hard sciences and engineering. In policy terms this means that actions should be launched to address the shortages in these specific areas.

MNEs are active in shaping the curricula of graduate and post-graduate programmes. They have representatives in university governing boards, take part in committees evaluating faculty programmes, sponsor research graduates, offer training facilities and so on. In countries such as the Netherlands and the UK a joint position as university professor and in a MNE R&D research lab is quite common. In Germany this type of mobility was uncommon. Human mobility between MNEs and the public research infrastructures is an important mechanism for building networks and establishing tighter collaboration patterns. National **regulations** such as higher education laws that restrict these interactions between universities and enterprises, will hamper the knowledge flow between important actors in the national innovation system.

The protection of **Intellectual Property Rights** was only a prominent issue for companies active in the life sciences. Here a restrictive ethical and legal framework to develop new technologies influenced investment decisions in favour of areas with fewer restrictions. A closer European co-ordination on these issues would prevent that national governments compete on this issue, at the cost of the quality of life of some Europeans. In Germany the debate on ownership of patents was an issue for debate for MNEs, since ownership is spread

over as many individuals as have contributed to a certain research result. This was considered to hamper the negotiations on license agreements between companies and research organisations. Some European guidelines on how to deal fairly with the patent licensing could improve the exploitation of research.

**Although all MNEs agreed that national and European R&D subsidy schemes are interesting to explore new technological paths, and establish new partnerships, the schemes do not have the critical mass to influence R&D location decisions.** In comparison with their internal budgets for R&D the public funding was relatively small. The funded R&D projects are not used to develop strategic research in core company technologies, rather areas that could be of interest for the future. MNEs find that the normal procedures are too slow to really use them to develop leading edge technologies. The policy implication is that there is no point in designing R&D subsidy schemes to the specific needs of the large multinationals, with the objective to embed them in the country. Indirect policy actions aimed at improving the overall conditions for knowledge creation, skills development and innovation will have a longer term impact.

In relation to the specific national systems of innovation the main conclusions depend on the role of home-based versus the host-based multinationals.

**Germany** showed a relative large share of home-based multinationals with still a centralised R&D (and patenting) strategy. A difficult interaction between industry and research, particularly universities is the key policy issue for the future relationship with its home based multinationals. The cultural gap between the two parts of the system is still immense and mobility relatively low. A key policy priority should be to establish better incentives for the HEI system to work together with industry and to lower the barriers for human mobility. Given the global search for excellence the German policy approach to support regional ‘Kompetenzzentren’ existing of a mix of public and private R&D actors, is very appropriate to embed home based multinationals as well as to attract research investments by host multinationals.

The **UK** with its high share of host-based companies that perform research has benefited from a historically built reputation in science excellence, particular in its Oxford and Cambridge institutions. It is also related to other European headquarter functions which the UK has taken over the past decades, with London as a magnet for general business investment. Its more entrepreneurial culture has given the UK a European lead in creating high-technology start ups and venture capital for new technologies. Maintaining this excellent position in a wide field of science areas will be the main policy challenges for the coming years, particularly after a period of cut downs in spending on basic science.

The **Netherlands** which has been traditionally dependent on a small number of multinationals has developed close ties with its national champions in terms of R&D policy. The study shows however that direct support for R&D in the form of financial incentives is less important than providing an overall climate that is conducive to innovation. The lack of clear international profiles of science excellence where Dutch science can compete with the world best, in combination with severe skill shortages in key technology areas, could deteriorate the system’s interaction with the leading MNEs. The attractiveness of the Netherlands for host multinationals based on R&D expertise alone will be modest. The low- key policy efforts for start-ups, is another issue for concern given their role as R&D partners.

**Ireland** has hardly any Irish-owned multinational firms that have an impact on the national innovation system. The host multinationals which perform a large share of Ireland’s business R&D are only recently establishing networks with the remainder of the national innovation system, such as its universities. The research resources of Ireland are too small in absolute terms to really influence R&D location decisions or to provoke major MNE investments in their country. Neither has Ireland come out of the patent statistics as a country of inventors and MNE subsidiaries with considerable own innovative competences. The Irish government has understood that its main challenge is to increase the quantity and quality of the NSI in order to embed the host companies and remain attractive as investment location. It has decided to boost its government spending in this area radically. The next bottleneck asking for policy action, is finding the people with skills to perform these research tasks.

Summarising, research excellence and a highly skilled workforce are the key assets on the basis of which both home-based and host-multinationals make their R&D investment decisions. For national policy makers this means that to tie home-based MNEs as well as attract foreign MNEs, a permanent upgrading the quality of the national system of innovation and its people.

### 3.3.2. OST results and methodology on S&T Co-activity in Region: an Insight in Geography of Knowledge-based Activities in EU

The aim of the project is to study the potential of regions, in Europe, from the point of view of the "knowledge-based society" where economy, technology and science combine. The idea of virtuous circles of interactions between the three activities has given rise to many works in spatial economics, regional economics, technical change studies. A central hypothesis is the existence of spatial scientific externalities, stating that the industrial firms, especially those committed in technological R&D (and among them multinational firms), draw advantages from the presence of nearby academic centres.

The purpose of this study was:

- a) to build a typology of regions, in Europe, from the point of view of their commitment in the two dimensions of the knowledge-base society.
- b) to roughly assess the potential of localised S-T spillovers or transfers in regions, through an insight in co-locations of science and technology (empirical co-location, whatever the causes).
- c) a step further, to investigate regularities in the spatial specific linkage science-technology, when controlling for the role of underlying variables, population and GDP. This is carried out both for "all fields" and for the sub-field electricity/ electronics/ instrumentation with a strong commitment in new technologies of information and communication.

#### A. Context

There is a wide consensus over the economic role of knowledge in growth, employment, competitiveness. Scholars have brought up the idea that knowledge was not only a new factor of growth, but a basic component of an emerging form of society. Although this model is a controversial matter, the so-called "Mode II" scheme (Gibbons et al., 1994) successfully drew attention on the complexity of interactions (between institutional players, - universities-governments-industries; between disciplines; between science and technology) that shape the knowledge-based society. Some of these interactions are "mediated by distance", i.e. can better take place in geographic proximity of players, depending on the form of knowledge involved.

A classic hypothesis is that codified forms of knowledge allow easy and low-cost circulation of information (Polanyi's hypotheses, Dasgupta & David, 1994). This circulation is enhanced by new means of communication, and fully benefit from electronic media. Tacit information does not travel as such, and asks for direct communication, mediated by distance. As a result, tacit forms of information could be better exchanged at short distance, for instance within a campus or a city's borders, while circulation of science published in journals, or transferred through electronic means of communication is not constrained by proximity. However in many cases tacit and codified information are intertwined in several ways. For example tacit information may act as a facilitator for the transmission of codified knowledge. If direct information flows count, the availability of skilled manpower (universities as recruitment base, mobility of researchers) also plays an important role in localized dissemination of knowledge.

In this work we examined a particular type of interaction, science-technology, at the scale of Europe seen as a set of 450 regions. This scale is too fine-grain to represent areas where a regional policy ("regional systems of innovation", with an institutional background) is effective, but is appropriate for studying potential of short-range communication. Our question could be put this way: "is geography of science and technology favorable to local science-technology exchanges?"

The science-technology relationship is usually addressed in terms of spillovers. In the narrow sense, *"Knowledge spillovers (are) positive externalities of scientific discoveries on the productivity of firms which neither made the discovery themselves nor licensed its use from the holder of intellectual property rights. [But in some occasions] all parties involved (government and other funding agencies, universities, professors, and enterprises) are or can be connected by contractual and/or ownership ties in competitive markets"* (Zucker et al., 1994, p.65, 79). This stresses that localized exchanges may take many forms in addition to regular spillovers. A rich literature has emerged in the decade on spillovers and other transfers. For example, Jaffe(1989), found evidence of geographically mediated spillovers from university research to industrial innovation in US regions. Later the same author (Jaffe et al., 1993) investigated with great detail the interest and caveats of patent-to-science citations as tracks of technological dependency over local

academic activity. Audretsch and Feldman (1996) showed the linkage between concentration (industrial clusters) and the existence of knowledge externalities, with the hypothesis that these spillovers are more prevalent in knowledge-based industries, assimilated to R&D intensive industries. Less optimistic views about the importance of spillovers are expressed in Rallet and Torre's works (e.g. 1995).

Another classic approach of spill-overs is the study of geographic concentrations and co-locations, including for fine grain lattices (especially in the US, see Anselin et al., 1997). Co-location of science and technology activities in the same region is necessary but not sufficient for proximity interactions. A high level of S&T co-locations creates a potential of exchanges, possibly enhanced by proximities in thematic specialization, but of course does not guarantee that effective spillovers or transfers take place. Moreover, in a dynamic view, co-location may be both a cause and result of exchanges. In this study we focus on concentration and co-location aspects.

Is co-location of S&T only an empirical reality in largest regions, that concentrate most of European production in science and technology? Or is it a prevalent regularity over a wider range of region sizes, suggesting a geographic "law" of coincidence between outputs of academic activity and of technological research? The country dimension, through historical determinations as well as institutional factors (National Systems of Innovation, see Freeman, 1987, Lundvall, 1992, Niosi & Bellon, 1994, Amable et al., 1997, also investigated in other folders of this TSER study, ex. Barré et al., 1999), is expected to play an important role.

As there are some contrasted analyses about the role of firm size in the spillovers studies, we paid a special attention to the role of MNEs, using as a proxy the "large applicants" of European patents. Among industrial firms, large firms are recognized as playing a major role in technology control and use. Though their role is controversial in achieving breakthrough inventions, there is no doubt about their capacity to fund large R&D laboratories and to achieve a selective diffusion of innovation through their market power. The role of MNE in national innovation systems has been highlighted in many studies (for example Patel & Pavitt, 1991, Ruigrok & Van Tulder, 1995, Brechje, 1999). The hypothesis of a stronger coincidence of patents from large applicants with science-academic concentrations attracting MNEs labs, in comparison with patents of all origins, can be put forth. The alternative hypotheses is also classic in spillover literature, namely that small firms are more benefiting from local resources than big ones. As Acs et al. put it (1994, p.399) "*Apparently large firms are more adept at exploiting knowledge created in their own laboratories, while their smaller counterparts have a comparative advantage at exploiting spillovers from university laboratories*". Other arguments may be found, for example in Rotterdam School of Management and Cepremap contribution to the research report, against an overstatement of the attraction by science as a major attraction factor, when compared with the institutional factor and general business climate at national or regional level. The economic literature also highlights agglomeration effects, independently from the particular attraction of academic centers. In the present study, large applicants, and also hot-home based large applicants (see below), were considered.

Along with the "all fields" study, we carried out a sectoral analysis in a particular field. There is some evidence (e.g. Audretsch and Feldman, op.cit. 1996) that transfers are more likely to occur in industries with a strong technological basis. We zoomed on a particular area with a strong high-technology component, electronics/ electricity/ instrumentation (abridged EEI in the following). This field collects a large proportion of NTIC, and we can expect there a higher intensity of science and technology spatial connection than the average.

## B. Data

The study is based on the 3-years average 1996-1998. Dates are publication years for scientific documents and publication years (for all patent applications) for European Patents.

For patents as for publications, OST realized a regionalization of outputs, using mainly correspondence tables between postal codes and Nuts codes<sup>7</sup>. The lattice used is a fine-grain one, in 450 regions (Luxembourg not considered), based on Nuts3 level. However, to keep an inter-country comparability, some re-aggregations (especially Nuts2) had to be practiced in order to reduce the discrepancies between average region size for

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<sup>7</sup> the authors are much indebted to F. Laville, at OST, for the supply of elaborated data, especially on patents.

various countries. As in all spatial studies, results, especially correlations, are sensitive to the type and level of breakdown (Cliff & Ord, 1981)

Data on population and Gdp come from EUROSTAT, with some interpolations.

The database for science indicators used is a customized extract of ISI's Integrated Citation File. We limited to Science Citation Index and Computer and Mathematics Citation Index. Assignments to Nuts regions have been made by OST. A residual class of publications could not be assigned. This "non-Nuts" class represents 0,6 % in the period under scrutiny. The most affected countries are Germany and UK, and especially Ireland. For indicators, usual OST counts and classifications are used.

Patents data are from EPO, including European Patents and Euro-PCT. This is a rather selective measure of patents, implying a strategic commitment of applicants on several national markets. Usual warnings about use of patents as a proxy of technological activity apply (see Pavitt, 1985, Grupp, 1999). "Large applicants" were defined as applicants with 5 patents/year or more. As well as for scientific publications, a residual class of non Nuts relates all patents where no correspondence between postal codes and Nuts was found. For patents counted by inventors' addresses the ratio of non Nuts regions is about 7,6 % in 1998, and especially marked for Germany. Not home-based patents are also studied, they are defined as patents with applicants controlled by mother companies located in a foreign country

For the specialization and thematic correspondence features, we use current OST-INPI-FHG classification in six large technological fields. As for science, a classic diversification index is computed for each region.

In addition, we built a tentative "concordance table" giving for each region an estimation of the thematic correspondence between science and technology. Though interdisciplinary transfer are not excluded - they can be the source of major innovations - the large bulk of science-technology linkages is expected to take place within the borders of large S&T thematic areas. For instance "chemistry" may be by and large considered as a category shared by science and technology. Though including some findings on citations by Schmoch at al. (2000), this table has a very different scope and substitutes to the rigorous and restricted view of these authors a much looser approach.

The definition of the sectoral study on EEI field is on both sides (S&T) a macro one. We selected two fields out six large ones of OST-INPI-FHG patent classification, and on the science side four sub-disciplines assumed to have strong linkages with these two fields: applied physics, optics-electronics-signal, informatics-computer science, biomedical engineering. Detailed definitions at the IPC classes level, and at the journal or document level for scientific publications, would be necessary for a more ambitious micro-approach.

Methods used in the study are specific of each chapter (typology, gross co-locations, S&T relationship) and shortly described in the results section below.

## c. Results

### a. Typology of regions

We know from prior studies (for example OST works, Barré et al., 1999; Zitt et al., 1999), that the picture of S&T European production at the regional level is marked by very strong concentration phenomena, and that this remains true when controlling for the variable population. When looking at the relation between S&T output and population, or in an other perspective between S&T output and per capita output, it comes that generally speaking, the larger the output, the larger the per capita output. Taken separately, these two criteria may lack robustness, but their combination, declined for science and technology, seems appropriate to found a typology of regions from the point of view of knowledge activities. Using rank treatments, these four elements allow ordering regions in Europe. We eventually grouped regions by couples of deciles, from class 1, of smallest regions often showing quasi-zero production in either activity, to class 5, of leading regions. Class 5 represents ca. 67% of publications, 58% of patents, 64% of large-applicants patents, 59% of not-home based large applicants' patents.

### *main sequence*

The representation of countries among classes is most uneven. The North-South polarity, as expected, structures the European landscape. In peripheral countries, and also Italy and France, a majority of regions is

found in classes 1 through 3. France, clearly on the southern side from this point of view, shows a profile fairly similar to Italy. Mediterranean countries are still lagging: Spain has no region higher than 4 (and very few in 4), Ireland no region higher than 3, Portugal and Greece no region higher than 2.

In Northern and Nordic countries, classes 4 + 5 are the majority. Some similarities of profile are noted between Sweden, Finland, Netherlands, where class 5 captures half of regions, and Belgium and Germany, where it captures more than a third. Denmark and Austria stay in the middle, with a balanced profile between classes 4+5 and others.

Reading results the other way, the dominance of North among the top region class is conspicuous, with nearly 40% of class 5 provided by German regions, and nearly 20% by UK regions. France accounts only for 12%, to compare to relatively high scores of Netherlands (9%), Sweden (6%), Belgium (4%).

A strong involvement of large applicants is observed in regions belonging to the top "main classes", in terms of percentage of all patents. Their proportion in class 5 is 43.4%, and decreases continuously through 16.4 % in class 1.

#### *deviations: preferential S, T, E orientations*

An important feature of regions is their relative involvement in one, both or neither dimensions of knowledge production. The orientation of the region was determined using a threshold on ranks differences (on values and per capita values) of publications or patents. Gdp data were also considered in the comparison. Orientations or "vocations" are denoted S, T, E or for mix ones SE, TE, ST, or when no significant orientation is found, STE. The assignment can be considered as robust since changes in threshold practically do not shift the vocation of a region but only determine the transition from a given class to the default 'STE'.

The fact that the classes of typology are built on knowledge-based activity criterion can explain that ST orientation is a preferred attribute of class 5 and that, conversely, the orientation E privileges class 1 and decreases when the ST production grows. One-way vocations in science is more frequent than in technology (in counterpart, TE is more frequent than SE). T-oriented and S-oriented regions are less frequent in class 5. TE proportion peaks in class 3 (not frequent in 5), SE regions peaks in class 2.

The default category (STE, no significant orientation), mostly represented in class 5 as seen above, is also not infrequent in class 1. The representation of STE and especially E in class 1 concerns in fact "quasi double-zero" regions for knowledge-based activities and can be considered of little practical significance. These results suggest that, with the exception of the quasi double-zero regions of class 1, the level of specialization towards science or technology is inversely related to the size, in other words, class 5 is more homogeneous and other classes appear to be polarized in either activity. This can be observed when summing T+TE and S+SE proportions, and is confirmed by the statistical study of the relation science-technology.

The main point remains the composition of the top "main class" of leading regions. A large majority of this class is represented by the no-orientation category STE (about 40% of the class). Clearly involved in S&T, but with also a leading position on Gdp, these regions show a balanced leadership, they are "strong ones" in every respect, and natural candidates for intensive localized transfers.

Moreover 22% of the leading class falls in the category ST, also deprived of science or technology preference. This corresponds to a family of regions specifically involved in knowledge-based activities, with economic activity at a relatively lower level. Only ca. 25% of the top-class regions have a single orientation in either science or technology. As expected, the first are mostly UK regions, the second medium-size German cities.

Looking at the national contents of categories, the well-known scientific vocation of the UK proves to be spatially distributed: one quarter of the regions are science-oriented, and one half when adding SE and ST. A minority is technology-oriented. The traditional contrast with Germany, a strongly technology-oriented nation, is also confirmed. Very few German regions are science-oriented (9%), while T and TE orientations each gather about one quarter of regions. Netherlands and Germany profiles are somewhat similar. France has also many TE (and also T) regions, but also some science-oriented ones (S: 13%).

Mediterranean countries go further than the UK in scientific orientation, with a nearly exclusive commitment: by European standards, they record neither T nor ST regions, and very few TE ones (none in Spain, Portugal, Greece, 9 in Italy). Italy has quite a high number of E-regions. This category without knowledge preference is mostly represented in Italy (64% of the class) and in Germany (6%), and residual elsewhere.

These observations can be linked to previous ones about national presence in main classes. When crossing the orientation with main classes, we witnessed another aspect of the North-South polarity. In northern countries, a majority of regions belonging to "small" classes (1 through 3) exhibits a rather technological orientation, whereas in southern countries, "small" regions are rather science or economy oriented. This can be connected with our earlier findings stressing the "inter-national" roots of technological inequalities, and the "inter-regional" root of scientific inequalities (op.cit. 1999). In less rich countries, the average level of technology is often so low that even a moderate inter-regional concentration leaves many regions with poor patents figures, enhancing the "scientific" or "economic" vocation in relative terms.

Combining main classes and vocations assignments into a synthetic representation (factor analysis), the respective positions of countries is assessed, with in mind the OST-CEPREMAP countries classification (see WPB). One observes the distant position of the OST-CEPREMAP "Mediterranean group", clearly identified, and mostly characterized by small regional outputs, and scientific/economic orientation. The group of "social-democracies" NIS (Sweden, Finland) is disconnected here. Within the "European core", Austria, Belgium, Denmark, France, Germany and the Netherlands appear to be part of a fairly homogeneous cluster in the center of the map, with Germany rather on the TE-ST side. But Italy and above all Ireland are outliers, and closer to the Mediterranean group. UK, as the European representative of the "Market-Based" family, is rather close here to its European partners.

In addition, other dimensions of regional orientation, such as the balance between ranks in output and per capita output, the thematic diversity, and the correspondence between S&T specialties, were addressed. Diversity and S&T concordance reach a maximum for top classes.

#### b. Science & Technology "Gross" Co-location

Beyond the evidence of an elite of wealthy regions, with balanced positions in S&T and hence theoretical advantages for science-technology transfers, the question arises of a more general relationship, in a large range of S&T size, between science and technology activities. This question was approached first by simple correlation studies ("gross" co-locations). A strong correlation will indicate that a balance exists between science and technology activities in a large scope of sizes. An implicit hypothesis (disputable) is that this balance of publications and patents resources will favor S&T transfers. Conversely, a low correlation will suggest that exceeding capacities either in science, or in technology, is the rule, a situation a priori not suitable for useful localized exchanges.

The study was based on Pearson correlations on logs, and also rank correlations, and conducted both at the European and the country level. An important option was keeping or discarding class 1 (lagers). These peripheral regions, with very low production in both science and technology (and sometimes with very low Gdp), yield leverage effects on all correlations analyses, so that the hypotheses of linkages between variables tend to be favored whereas they mainly reflect the trivial opposition between wealthy and less favored regions.

Besides, we introduced the "concordance coefficient" C between science and technology (in terms of thematic specialization), mentioned above. Finding a better linkage between S and T using this coefficient would show that the spatial empirical relation between "consistent" science and technology is better than the overall relation. The substitution of selective measures of science, citations ("most visible science") instead of publications, brings a further complexity without much improving general results. Co-location was studied for all patents, large applicants patents, not-home base patents. For patents-science correlations at the European level, the introduction of the thematic concordance index C always slightly increases the correlation. However this is not true for analyses at the country level in most cases.

The science-technology correlation is moderate (0.59; without class 1: 0.32) for all Europe but clearly increases when controlling for S-T concordance (0.65; without class 1: 0.36). Using citations instead of publications slightly improves the figures. At the country level, a high-level of geographic coincidence between S and T (>0.8) is recorded in Sweden, (Greece, Finland). Denmark, France, Spain, Netherlands, the

UK are in the middle (>0.55). Others show little coincidence, especially Germany with a very low figure (0.15).

The gross linkage of patents-Gdp is superior to patents-publication one, and resists the removal of class 1 (resp. 0.69; 0.58). It remains high in terms of per capita values (resp. 0.62; 0.60).

Does the picture of science-technology co-location change when restricting to "large applicants patents" instead of using "all patents"? In terms of production, the linkage large applicants-science appears systematically lower than all patents-science, with very few exceptions. In terms of p.c. values, coincidence is lower, the conclusion is unchanged. When limiting to "not-home based" large applicant's patents, the effect of spatial distribution of science is usually stronger than for all large applicants, but not reaching the level recorded for "all patents". To conclude on these points, the hypothesis that large applicants patents show a better connection than all applicants patents with academic production cannot be sustained, if a general geographic regularity is meant. But of course it should be kept in mind that the leading class, as mentioned above, concentrate about two-thirds of both science and large applicants' patents.

In comparison with "all fields" together, the science-technology correlations are slightly improved when restricting to the field EEI. An inversion of rankings, technology-science becoming greater than technology-Gdp, is even noted for Denmark, Spain and the Netherlands (densities), Finland, France and the Netherlands (production).

Naturally, concentration of population is a main substrate for concentrations of S&T. A look at correlations between population and other variables, shows that as expected the best linkage with population is obtained for Gdp (0.94; without class 1: 0.92), then for publications (0.72; without class 1: 0.63), and last for patents (0.55; without class 1: 0.40). Partly neutralizing the effect of population (by using per capita values or "densities") naturally tends to depress the level of linkage between other variables, for instance S and T. Publication (or citation) correlation with technology, in per capita values, are still much lower when the class 1 is removed. The next section reports a more systematic attempt to control for eco-demographic effects.

### c. Science & Technology specific relationship

We limit to a log-linear simple model with one equation  $T=f(S,E)$ . The dependence of T upon E may be seen as a natural one, considering that the capacity and propensity to patent reflect the behavior of the leading edge of industry, agriculture or services. T can be interpreted as a selection process over E. In the same view T' (large applicants) results from a selection over T. The dependence of T over E has been also expressed in a dynamic way since Schmookler's works on time series. The dependence of T over S reflects the spatial coincidence of technology and science, whatever the underlying rationale. Though the choice of T as the dependent variable primarily evokes a scheme "à la V. Bush" (which enjoys a certain revival with Narin's works in bibliometrics (1997) and Jaffe's ones in economics), the direction of causality or rather interaction, is a matter of many debates.

#### *global model*

As all variables are basically dependent on population, a control for this variable population should be implemented. We have considered two forms:

$$\log T = a \log S + b \log E + c \log P$$

in production values, with free specification of the population P.

$$\log (T/P) = a \log (S/P) + b \log (E/P)$$

in per capita values.

As we are first interested in the hierarchy of determining factors, the models are mainly based on standardized variables (at the European level), without intercept. Collinearity can be neglected at the European level for both models, but remains very serious in half of cases at the country level when population is specified. We also chose to keep a pessimistic estimation of the ST relation, by discarding class 1, an option which has the indirect advantage of alleviating the zero values problem in logarithmic representation.

The best fit with "all patents" as the dependent variable, when specifying population, yields a weak and not significant science coefficient and an (adjusted) R-square 0.46 (with or without control for S&T concordance). This is not a too bad fit with respect to the context. It however suggests a lack of identification, and invites a cautionary interpretation. For the model using "densities" (no specification of population), the

R-square is 0.36, the control for S&T increases the science coefficient, which is still not significant. In both models the Gdp coefficient is always significantly higher than the science coefficient.

Restricting to large applicants (densities model) lowers the goodness-of-fit. The science coefficient is very small but significant in the case of control for S&T concordance. Restricting to not home-based patents does not improve the fit but the science coefficient is higher. The practical conclusion should be very prudent, given the poor quality of fitting. The lack of identification for the large applicants' model may be linked to the role of other variables likely to strongly influence the location of MNEs, such as the institutional background both at the national and regional level.

The European perspective aggregates strongly contrasted situations. When looking at country models for all patents (densities), Sweden, Belgium, Netherlands, UK, and Denmark record pretty high values for science, but only significant for the three last ones, and always significantly inferior to Gdp one. Among these countries only Denmark shows an acceptable fit. No positive and significant effect of science is recorded elsewhere. When comparing these results to the direct correlations, much higher, and taking into account the modest quality of the global fit obtained here, S&T spatial coincidences as an autonomous phenomenon stand at best on the edge of visibility. Looking at large applicants, the conclusions are practically unchanged, the science coefficient being now significant for Sweden and Spain, the latter with an acceptable fit.

Zooming on the EEI field with these global models does not yield a strong improvement of the general quality of fitting. However the coefficient of science is notably better, both in the model with specified population (especially for large applicants) and in the densities model. It becomes significant e.g. in the density model for EU, with or without S&T concordance. For large applicants' patents, the global fit remains low, but the science coefficient is better than for "all fields" model.

#### *dichotomous model*

A modification of the model was tried, at the European level. Starting from the typology and the examination of the ST (p.c. outputs) scatterplot, which clearly suggests a scarcity of "no-vocation" profiles among middle and small regions, we identified two families of regions as aggregates of categories of "orientation": the "scientific" family (resp. S+ SE+ ST+ STE); the "technological" family (T+ TE+ ST+ STE; E also included); the families overlap for ST+STE. Separate models were tested for each family. Class 1 was discarded, considering that "no-vocation" profiles are largely the result of quasi zero figures.

When comparing to the global model (EU level, densities, class 1 excluded), highly significant coefficients for science are recorded, both in the "scientific" (with a R-square 0.56) and the "technological" family (low R-square 0.27). R-squares are substantially improved by the removal of a few outlying regions. Gdp effect is not significantly higher than science effect. For large applicants as well, the science coefficient also becomes significant, in both families, in fact stronger - but not significantly - than the Gdp coefficient. In the version with non-standardized variables, the elasticity of technological output or densities as a function of science is quite high in the "scientific" family, albeit inferior to elasticity to Gdp. The type of geographic coincidence revealed by the dichotomous model is "unbalanced", we could interpret this by stating that the "scientific" family shows an excess of scientific supply with respect to the technological (localized) potential of absorption, and the "technological" family an excess of local demand for science.

In the EEI field, the dichotomous model brings a noticeable improvement over the "global model". It yields for all patents (EU level, densities form), a better fit (R-square from 0.28 to 0.49 in the "scientific" family), and a much clearer linkage to science (the difference between science and Gdp coefficients is now significant in favor of science). For large applicants, the overall fit is not bad (0.46) and the science coefficient is also significantly higher than Gdp's in the "scientific" family. With respect to the unbalanced situation noted before, a real phenomenon of geographic coincidence of patents with academic activity seems at work in this particular field.

#### D. Summary, Conclusions and Policy Implications

The question of geographic coincidence of science-technology activities was addressed at the European level, using a breakdown into 450 regions. Geographic coincidence is a necessary condition for emergence of local spillovers or other S&T transfers.

A typological work was carried out, first by ranking regions on S&T output and per capita output, and distinguishing for convenience five groups, from the leaders to the very weak regions; then additional

characteristics were depicted, first of all the general orientation towards science, technology, or economic activities. The leading class concentrates almost two thirds of European S&T output - a confirmation of previous findings about the degree of concentration of science and technology in Europe – and a majority of leading regions displays a rather balanced activity between science and technology. The leading class also exhibits the best thematic concordance between science specializations and technology specializations, and a stronger representation of "large applicants" in patent production. As far as a geographic potential of localized spillovers/ transfers is concerned, the regions belonging to the leading class can mobilize masses of knowledge in both areas, appropriate knowledge and academic knowledge, giving room for creative exchanges between science and technology.

Nevertheless, other classes cannot be neglected, and the question remains of the regularity of the coincidence between S&T over a wide range of regions "sizes". An insight in geographic co-location between science, technology and other variables such as Gdp and population leads to the conclusion that technology-science correlation at the European level is quite noticeable, but much inferior to technology-Gdp one. This is also true for most individual countries. The empirical linkage of S&T is interesting on its own, to assess the gross potential of exchanges between S&T currently available, but says nothing about the underlying factors, especially eco-demographic substrate, without talking of the mechanisms.

The next part of the study precisely aimed at isolating a possible specific science-technology connection, independently of other determinations. At what extent the spatial distribution of technology can be explained by science vs. economic substrate? Using multiple regressions, we found that, considering all regions together at the European level, the specific effect of science is at the limit of statistical significance. Gdp is a significantly better predictor of patents geographic distribution, in any form (all patents, large applicants' patents, not-home based patents...). Again, at the individual country level, this result is prevalent with few exceptions.

However, all these correlations studies were "global", taking all regions regardless of their specific vocation. Investigating more precisely the S and T relationship, we found that the collection of regions could be considered as a mix of two sets to be defined after the typology above, the "scientific" family exhibiting a science orientation (and possibly others), and conversely the "technological" family. The two families are overlapping in the area of leading regions, with balanced vocations, but tend to split elsewhere in a bimodal distribution (the quasi-zero regions should be excluded). When treating separately the two families, the effect of science becomes significant. For the science family, a predictive model will show a quite high elasticity of technological output as a function of the scientific output.

Those remarks are still reinforced in the sectoral approach. Introducing a "thematic concordance" measure in all-fields studies is sometimes helpful to make clearer the role of science distribution. Restricting to a technological area with high-technology involvement, and corresponding scientific specialties, gives evidence of the autonomous character of the geographic linkage science-technology.

In terms of geographic regularities, the coincidence between "large applicants" patents and science is rather inferior than for "all patents", with very few exceptions for individual countries. There is a slight indication that "not home-based" are somewhat more connected to science than "large applicants' patents" as a whole. If no general geographic rationale tends to tally large applicants' presence and academic location, the concentration of both activities in large metropolitan areas however creates a large theoretical potential of exchanges. In secondary centers the criterion of academic presence seems less relevant for MNEs' attraction.

Limitations of the study are of several kinds:

Regional data are still imperfect for a decade's retrospect, and we had to stick to a static point of view. A longitudinal study with more extensive retrospect than in the previous OST studies would be necessary to address convergence issues for science and technology production, and also (see below), to provide an insight into dynamic relations.

The analysis was limited to a particular breakdown, and did not cope with inter-regional similarities (spatial correlations between nearby regions, for example; distinction between laggards close to large concentrations and isolated ones...). Homogeneous zones in terms of output and vocation, could be found covering larger

regional areas, for instance in Germany and northern Europe. Trans-frontier regions are also worth further examinations.

The network dimension would also deserve an extensive study, in order to compare local logic (for example intra-regional co-publications, nearby regions collaboration) and global logic (co-publications within archipelagoes of large cities, inside or outside the country). On the technology side, co-patenting is however more difficult to interpret.

A more systematic approach of science-technology in strategic areas would also be of value. The evidence we found that the geographic linkage between production of patents and publications is tighter in a high-technology field, needs to be more extensively tested. This is a strong incentive to extend sectoral studies.

More fundamentally, the study was limited to the geographic coincidences. As strong as they might be (and there are usually moderate), spatial coincidences do not prove the reality of spillovers or other exchanges. The geographic patterns may be interpreted both as a result and a cause of S&T interactions. These interactions can rely on many mechanisms, largely studied in literature: improvement of performance through better communication, availability and migration of skilled manpower (students, scientists), attraction of enterprises, creation of enterprises and other complex co-development patterns of university and industry research.

These results and their limitations are strong incentives to extend the research in these directions.

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To conclude, Europe of science and technology displays a large variety of situations. Heterogeneity is the rule. The diversity of national innovation systems, and of infrastructures rooted in national economy history, has coined contrasting geographic patterns of science and technology location. The variety of regional orientations is also quite large. The typology we proposed allows a precise profiling of regions from this point of view. The "national effect" can be indirectly seen through the typology, with striking contrasts between countries as to their representation among classes of the main sequence, and categories of S,T,E orientations. Results are by and large consistent with OST-CEPREMAP's countries typologies.

The concentration of S&T outputs and resources in a minority of regions in Europe, probably due, in part, to virtuous circles of endogenous mechanisms, is a reality. In this "elite" of regions, powerful both in science and technology, both in S&T production and density, both in SMEs and MNEs patenting activity, the geographic conditions for large amounts of S&T localized transfers are fulfilled.

If we don't focus on the leading core but on the wide scope of regions with various S&T sizes, the geographic patterns appear to be moderately favourable. The technological activity tend to make proportion with the academic one, if only because of the demographic and economic background, but in a pretty loose way. A divergence in the vocations of the regions, science or technology-oriented, appears as soon as we quit the "elite" class, which also means that the overall potential of exchanges can be hindered. When looking separately at the "scientific" and the "technological" family of regions, geography of science becomes a significant predictor of geography of technology, less than Gdp when all fields are considered, but more than Gdp when the focus is set on a high-technology field.

This suggests that in the "scientific" family of regions - not a majority in Europe - mechanisms exist that proportion the technological development and the scientific development, but within paths with unbalanced activities – in contrast with the situation prevailing in the leading class of regions. It is reasonable to assume that at the regional level – but this cannot be demonstrated solely from our findings – fostering academic resources will tend to develop the technological power along this trajectory. On the other hand, further studies would be necessary to assess whether variations of the technological potential of regions belonging the "technological" family can affect the academic potential, perhaps through various forms of funding within an appropriate institutional framework. Another point of importance for S&T policy is the case of quasi double-zero S&T activity, that would be worth a special attention. Is there a slight chance that mechanisms triggering a catch-up process at reasonable costs, could be put at work?

### 3.4. Questioning the “internationalisation” of innovation systems (Work Package D)

#### 3.4.1. Introduction

The present phase of internationalisation is mainly characterised by the dense nature of the linkages that have been organised at international levels. Economic agents have already set up or can dispose now days of vast networks or links of international relations. They can therefore define their strategies at an international level more than ever. This shows not only in the diversified nature of transactions (of which intra trade is only one sign) but also in the wide range of countries concerned as well as in the large number of institutions involved from regional authorities to NGOs, including all kind of institutions from universities to professional associations.

In this broad web of relationships and tangible and intangible transactions, the specific setting of institutions first considered as national systems of innovation (NSI), soon expanded in the form of social systems of innovation and production (SSIP) are bound to be affected and transformed accordingly.

We take seriously this question on the likely development of innovation systems on the basis of various research works including the ones done in the course of this CDIS-TSER project. Basic assumptions could be that these systems erode and evolve towards one unique form of institutional arrangements. This convergence thesis is not in itself a simple hypothesis as obviously systems evolve slowly and the dynamics of systems of innovation would then be one of a long transition towards a unique institutional pattern. This long transitional path would then be opened to all kinds of perturbations. The dynamics of the bunch of interacting innovation systems would then be a rather stochastic process.

In a more structuralist approach one would say that the very structure of SSIP in the context of a process of specifically defined internationalisation would be likely to determine a set of specific reactions where the systems can become more or less effective and would at some point be forced to adapt.

Our approach is thus centred on the dynamics of the various institutional configurations at work in what is called systems of innovation. We reckon from the start that the dynamics of the sets of institutions are strongly determined by the various complementarities that link together in various ways subsets of institutions. We add to this observation that institutional changes in one country tend to follow at each period specific trends of developments. At some previous period of “golden capitalism” these trends were much oriented towards changes in the wage-labour nexus. In the present period we retained that these trends are more centred around changes in the “forms of competition”, i.e. in the fabric of institutions that govern in each country how markets operate and how economic agents in general tend to set up arrangements of all kinds (to include the transactions which are not market transactions as such but do affect the functioning of markets as the actions of NGOs, professional or cultural associations, etc.)

We proceed afterwards in assessing the directions of change of the various SSIP and how it may affect their working and their future.

Still the lessons to be drawn from the existence of national trajectories seem retrospectively rather ambiguous. On the one hand the notion was mobilised to explain the success of some national 'systems' such as Japan (Freeman [1987]) and the peculiarities of many others (Denmark and the Scandinavian countries in general, France, the UK, etc.) On the other hand it was also used to account for the poor performance at the time of the US. See the studies around the Made in America project launched by MIT at the end of the 1980s, which clearly pointed at the deficiencies of some of the practices and institutional background of the US sectoral activities.

Seen with the eyes of the late 1990s the same call for specific influences of national institutional contexts is bound to express very different developments. The US hegemony seems to have been restored, Japan has experienced its worse decade for nearly half a century. France seems in the late 1990s in a much better international position on many grounds while the positions of Germany and Italy seem to have somewhat deteriorated.

Finally if there is a paradox in referring to innovation systems in an analysis of economic growth in times of increasing internationalisation, it is in drawing too rapid conclusions on their efficiency to affect in good or

bad ways governance and economic performances when these effects may depend on some broad characteristics of the overall context of the process of internationalisation (which includes the phase in which the internationalisation process is). In other words the laws of motion and inference of innovation systems are likely to be contingent. In particular the working of these systems will be differently affected according to the forms that the external challenges can take along time.

This common external challenge should be especially qualified respectively to the inner dynamics of institutions. It should thus be related with the precise dynamics impelled by the prevailing area of institutional changes, namely in the current period the forms of competition (which constitute a kind of hierarchy between institutional areas according to our approach of institutional change).

Lastly even if at some points in time some systems do appear to react in more successful ways than others (if only in terms of competitiveness) one should take a broad perspective and assess changes in ways that allow to follow the long term as well as the short and medium term evolutions. It may thus well be the case that some SSIP are more prone to take the advantage of a change in technological paradigm at its early stage while other take more time to mature a successful “country specific adaptation ” of the same technological phase. Referring to a new technological paradigm could be misleading if considered in isolation of the very context in which such technological change occurred. Change in context is thus assessed in terms of both internationalisation of transactions and technology diffusion between the mid 1980s and the end of the 1990s.

How then to assess this process of “internationalisation and technological change” and its effects on the complex architecture of SSIPs?

First we take an overview of the architecture displayed by the various components of the SSIPs in the mid 1980s and early 1990s as elaborated in other works of the CDIS project. The evolution of sub systems of SSIPs which are less directly exposed to international influences, concerning labour market, education, scientific specialisation, R&D activities, technological specialisation, is appreciated on the basis of Barré et alii (2000) (Work package B of the present report) and compared with previous work produced earlier by Amable, Barré and Boyer [1997]. We then look at some sub systems which are likely to be deeply transformed by changes in internationalisation. Full attention is thus given to the patterns of international transactions (by means of broad indicators on flows of goods, services and financial transactions) and to the changes in the structures of financial systems.

The next step focuses on some specificities of the present phase of internationalisation. Following the central shift in the forms of competition at work in most countries, changes in international technology transfer and in finance transaction systems are considered as two prevailing and revealing aspects of the current specific evolutions.

The development of various forms of financing at early stages of innovation has been one of the example of specific institutional change and “organisational” innovations to consider. Similarly changes in the ways technology is transferred internationally. Sources on the various means to transfer knowledge or on the practices of MNEs to internationalised their R&D (making use of the work package WPCb of the CDIS project) are analysed. The direct role that local agents, firms or institutions can have in shaping this technology transfer can also be checked referring to work package WPCa of the project.

Finally we try to elaborate on the results recalled in the previous sections to assess perspectives of evolution of the SSIP under view.

Challenges at this stage concern both the time and space of the evolutions, whether or not the national spaces will remain an entirely relevant level of analysis or should they be considered in some joint international architectures and whether the successes of some forms or SSIP are signs of transitory abilities to adapt or durable characteristics of some arrangements.

An important issue addressed in this study concerns the characterisation of the EU.

EU countries are dispatched in five of the seven groups of the final typology found in WPB which conversely shows that to the exception of the UK, European countries are specifically distinct from non European countries such as the US, Canada, Australia and Japan which feature in distinct groups.

A key issue is whether this diversity can be turned into a positive factor of adaptation. Looking at sub systems which are more exposed to international pressure help in that respect to point at the possible synergies between EU innovation systems.

#### 3.4.2. Expanding the data analysis to the sub systems of external relations and finance.

The various forms of international relations and the type of financial system developed in one country are bound to be major factors in the contemporary transformation of innovation systems. The importance of these sub systems must have grown precisely in the 80s and 90s while international transfers of technology and finance increased noticeably, following various paths in accordance with the pre-existing institutional context.

In our perspective looking at innovation systems the forms of internationalisation are major means of technology transfers. Conversely the financial system is a key element in the dynamics of innovation. It has to be associated in the first place to any project of innovation inasmuch as such project imply some financial transfer.

Both technology transfers and financial transfers have been undergoing deep changes in the last decades, and especially in the nineties when the regulations that constrained these transfers effectively underwent the broad deregulation process that was initiated a decade before<sup>8</sup>. Let us now review the configuration of practices and countries regarding these transfers as shown by the forms of internationalisation and the structures of financial systems.

##### A. Looking at technology transfers and at the forms of internationalisation

Transfers of technology that had been traditionally linked with the trade of equipment and the sales of patents obviously broadened their ways. With the development of intra trade flows (and the specific complementarities that this implies- detailed co-ordination of production ..and development of products as facilitated by the new relations between contractors via iso norms references) technological spill over could occur all along the line of trade flows. But on top of this extension, trade in services manifested important new means of transfer: from specialised business services to business travels, and also foreign direct investments (which, either in the form of green fields investment or acquisitions, imply some checking and transfer in technology of production and products). Beyond that as already mentioned international accords often bore on technology or on market access, which are all central figures in the process of innovation. Therefore even simple account of trade structure in goods and services, as well as data on FDI can help to feature some of the capability of countries to benefit from external knowledge or to diffuse some of its own know how.

We thus have run eight data analysis on the structure of the balance of payments (disregarding for statistical reasons more qualitative variables on accords or on MNEs cross-border activities or on the international co-operation of universities and research laboratories.

Much of what we can learn with the balance of payments data that we retained is thus linked to their sectoral dimension.

We thus analysed data at the level of 14 (?) sectors for inward and outward foreign direct investment, for imports and exports of goods and for the debits and credits in services (to which we added an analysis of the sectoral contributions to the trade balance) for 20 OECD countries. Detailed results of data analyses are given in annex of working package D of this CDIS project. The sectors which are structuring the readings of the various flows are thus respectively:

- for the inward and outward FDI: the presence of primary products, information technology equipment and business services (of which financial intermediation) is distinctive (see table A1-1), which is rather expected.
- for the specialisation indexes in export and import trade flows, the presence of equipment goods, chemicals, refinery, metal industry, or "traditional" industries(textile, wood, paper) is explaining, again as expected from current analyses on crude trade specialisation. Intra trade was not explicitly considered here and we therefore registered a more traditional view on specialisation.

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<sup>8</sup> As a matter of fact deregulation is a long term process which contrary to what many think did not become effective in most cases before the mid nineties, even in countries that seem to be in the front row as the US (see Catinat 1998, 2000).

- for the specialisation indexes in credits and debits in service trade, the distinctive variables are spread across most items: travels, communications, financial services, transports, royalties and fees.

All these variables led to various groupings of countries which again displays some variance that we can appreciate when comparing again with some average typology that we obtained directly, looking at the 7 data analysis and studying the frequencies with which countries belong to the same group.

**Table 1**  
**Structures of internationalisation: typologies of countries**

	U S	U K	C A	A S	N O	I T	S P	P O	G R	F R	B E	D K	S W	F I	A U	D E	C H	N L	I R	J P
	1	1	1	1	1	2	2	2	2	3	3	3	4	4	5	5	5	5	5	5
<b>Ifdi</b>	1	1	2		1	3				3			2	2	5	4		5		2
<b>ofdi</b>	1	1	1		1	1				1			2	2	3	3		3		3
<b>Exp</b>	1	1	2	3	3	4	4	4	3	1	1	1	2	2	4	1	1	1	1	5
<b>Imp</b>	1	1	1	1	4	3	2	2	3	2	3	3	?	5	4	2	3	3	5	6
<b>Deb</b>	2	5	1	1	3	3	1	1	1	3	1	?	6	6	4	6	2	6	6	6
<b>Cre</b>	5	4	3	1	2	1	1	1	1	1	4	?	3	3	4	3	4	5	3	6
<b>Tbal</b>	3	3	2	3	3	2	2	2	2	3	?	3	1	1	1	4	?	3	?	4
<b>Rbal</b>	5	5	2	1	2	3	2	3	3	5	4	4	4	2	4	4	4	5	4	6

Legend: Ifdi: inwards foreign direct investment, Ofdi: outwards foreign direct investment, Exp: exports of goods, Imp: imports of goods, Deb: debits in service trade, Cre: credits in service trade, Tbal: trade balance relative to value added, Rbal: relative contribution to the trade balance.

#### B. Looking at financial transfers and systems.

Similarly finance variables are likely to have taken a growing importance in influencing systems of innovation. The period has effectively been more and more characterised by a drive for innovation, even incremental product innovations, directly pushed by a constant search for competitiveness. This has required all kind of research and development investment, rapidly mobilised on more risky projects. This pressure has led to the developments of new forms of financing more directly specialised in innovative risky project. The whole story of venture capital gives a good illustration of this pressure. How this pressure is absorbed by each system in different ways depending on its specific nature. Thus it may less be the case to search for R&D funding itself than to set up capabilities to constantly differentiate product, get a better approach to markets, launch product packages more or less strictly tied with services, set up alliances on innovation projects or new reactive schemes of production and of distribution.

Structures of the finance system are thus likely to have been crucial in building up this responsiveness to markets.

We have run four data analysis on various types of variables in order to see how financial systems differentiated themselves and which characteristics were correlated with the better performances in terms of growth and innovation.

Table 2 presents the four typologies of countries obtained respectively for the banking structure, the tax systems, the structure of venture capital and the structure of institutional investment.

**Table 2**  
**Structures of financial systems: typologies of countries**

	U S	U K	C A	A S	N O	I T	S P	P O	G R	F R	B E	D K	S W	F I	A U	D E	C H	N L	I R	J P
	1	1	1	1	1	2	2	2	2	3	3	3	4	4	5	5	5	5	5	5
<b>Banks</b>	1	3	1	1	1	2	2	2	1	5	5	2	2	5	3	3	3	3	3	4
<b>Taxes</b>	2	5	1	1	5	3	3	5	4	4	3	5	3	3	4	4	2	4	5	2
<b>Venture</b>		2				3	3	3	3	1	1	4	2	5	3	3		5	1	
<b>Investors</b>	1	1	1	1	4	5	3	3	5	5	5	5	5	2	4	4	2	2		2

C. A typology based on exposed sub systems

We then tried to see which typology emerges as the most frequent (or dense) grouping of countries out of these international relations and finance structures.

Table 3 gives a rapid overview of this synthesis. In this grouping based on the 12 analysis of data on financial and internationalisation sub systems.:

- the core of Anglo Saxon countries, i.e. the US and the UK, plus countries with trade marked by the importance of primary resources such as Canada, Australia, Norway
- then we find a group of central Europa with Germany, Austria, The Netherlands, and Switzerland... (and Ireland (?) ...and Japan).
- France, for once isolated from Germany, is associated with Belgium and more surprisingly Denmark.
- While European Mediterranean countries go on forming one specific group.

The reasons for the changes (if compared with the typology drawn from Barré et alii (2000) are worth considering, due to the very different nature of the domains under view in each case.

**Table 3**  
**Structure of internationalisation and Financing**  
**A synthesis of 12 typologies of countries**

sub system	Principal axis of Analysis			Typology of countries		Characteristics of groups
	Side of axis	-	+			
C1	Axis 1	Import of transport Equipment,	Trade surplus in chemicals,	G1	AUS-CAN NOR-USA GBR-	Axis 2(-) (+):Importance of loans for Banks, Import of transport Equipment, Banking revenue interest, tax in Income and profit
						(-): deficit in electrical machinery, trade surplus in minerals product
C2	Axis 2	Trade surplus in chemicals,	Trade Deficit in minerals, inflows of FDI in manufacturing	G2	ESP-PRT ITA-GRC	Axis 1(-)
C3						(+): textile, trade surplus in minerals product, tax on specific good and services
C4						(-): import of computer related equipment, importance of financial assets in GDP, surplus in good, importance of loans for banks, chemical product
C5						
C6	Axis 3	Credit in international banking Activities	Trade deficit In goods	G3	FRA-DNK BEL-	Axis 3(-)
C7						(-): importance of loans for banks
C10	Axis 3	Credit in international banking Activities	Trade deficit In goods	G4	SWE-FIN	Axis 3(+)
F1						(+): outflows and inflows of FDI in manufacturing, importance of shares for banks
F2						Axis 1(+)
F3						(+): real estate and FDI outflows in business services, importance of loans for institutional investor, trade surplus in electrical machinery and in chemical
F4				G5	AUT-JPN DEU-IRL CHE-NLD	(-): import of transport equipment, importance of shares for banks

The distance existing between the structural indicators we use and the fabric of institutions we want to reflect upon may well explain some changes in typology The structures of the economy are supposed to reflect the patterns of rules and practices induced by the fabric of institutions. But changes in the institutional background take time before becoming manifest in the structural indicators we used. (see Barbier Theret [2000] for examples).

The typologies are effectively partially unstable, with some country jumping from one group to the other given the perspective taken. In contrast some couples are always tightly together in most data analysis such as the US and the UK or Portugal and Spain, or some Scandinavian pair.

To understand the meaning of these differences, to what extent they do reveal weak linkages within groups or simply transitory departures preserving the coherence of the groups one needs more investigations using specific information on the phenomenon under view.

### 3.4.3. Venture Capital and innovation financing

The importance of finance in innovation is often associated with the growing importance of venture capital. Such statement is justified to the extent that venture capital as a specific means of financing and monitoring investment first gathers many of the specificities of both market-based and bank-based finance and second has different expressions in different countries or SSIP, institutionally compatible with the existing sets of arrangements which characterise the SSIP.

Venture capital, involving screening and close monitoring, demands active governance. Therefore, it is more similar to an investment bank's type of involvement than an anonymous market for small shareholders. Venture capitalists do not usually possess the rights of a shareholder (no voting rights), they hold "convertible securities" rather than shares. Payments to venture capitalists are (partly) fixed and revisable according to the venture's successes or failures rather than decided by the management of the start-up.

Venture capitalists do not make all their investments all at once, funds are provided in different stages, and the venture only receives funds up to the next stage at each time. Seed financing allows the technological firm to produce a new good. If the new good cannot prove to be feasible or profitable enough, the venture may never reach the next stage, or the firm's management may be changed, etc.

Venture capitalists' strategy is that of exit. After a certain period, the successful firm is merged with another one or acquired or 'goes public' through an IPO (Investment Public Offering). Bringing new firms to the public allows to redirect venture capitalists resources towards the financing of new technological ventures.

One may expect some systems to be more prone to encourage venture capital than others may:

- systems where providers of finance are sophisticated enough (institutional investors) and large enough to have a diversified portfolio;
- market systems because venture capital-funded firms have to 'go public' after some time. If there is no liquid asset (shares) market, the whole success of the venture capital-funded start-up is jeopardised.
- Systems with patient actors (start-ups usually take time to become profitable businesses).
- But venture capitalists themselves are intermediaries, they need to find a source of finance which is willing to invest a part of its portfolio in long-term projects.

It could be investment banks in Europe just as well as it is pension funds in the US.

The basic financial system under view could sort out and take care of all projects, including the most innovative ones, with no need then for a new specific form of investment financing to develop (a question effectively raised in OECD (1996b)). Some systems are clearly more prone than others to develop such special category. Therefore it is an important stylised fact that all systems are by now keen to develop such specific category of finance scheme.

The form of specific intervention can be very different according to:

- the phase of the industrial project, which clearly makes the expertise of the future of the project more or less easy to rate (an highly technical rating ),
- the way in which the venture is supposed to end. Although it may not be a preliminary condition, how venture capital will be freed for another venture and how the project will reach another stage of financing, turns out to be a determining characteristic of the context of investment.

The origin of the funds to be invested is also a key characteristic of the venture. It may involve public or privates fund, and in this last category more or less institutionalised and organised agents of different financial importance.

The very structure of an SSIP is telling about the forms that a specific venture capital scheme may take.

*Looking at the stage of the project shows for instance a surprising difference in the importance of early stage projects in the US versus the UK (belonging to the same SSIP). In the UK, venture capital is more developed*

*than elsewhere in the form of buy out operations. France and Germany are also in opposed situations in this respect, with Buy-out being more frequent in France and early phase in Germany. Sweden is close to the UK when Denmark is closer to the expected Scandinavian pattern of social democrat SSI.*

*When looking at the origins of the funds a similar diversity between the structure of funds origins in Denmark and in Sweden calls again for attention. By and large data on the origin of funds also show that the role of business angels in Europe remains very limited*

To explain these differences in structures it is important to check whether they are linked with the levels of development of venture capital. Data does not point to any clear correlation between for instance the level of venture capital and the share of early project in the total (while it could have been a sign of maturity of the system that a fair share of early projects could be selected).

Two observations: the first concerns the crucial development of exit forms and chiefly second markets. So far they have only gained some importance in the US (where they attract foreign capital as well) and are only in an early stage of development in Europe and Japan (where it started, with some initial success, earlier than in Europe). A second feature is the sector of investment: Most of the investments are concentrated in the buoyant spheres of information and communication technologies or in the rapidly developing biotechnologies. So we tend to assume that the sectoral distribution of venture capital investment is not an issue which discriminate between countries and SSIP. As a matter of fact it is an highly and surprisingly discriminant factor. According to the OECD (1999) recent evaluation of technology development 78% of the venture capital in the US is effectively in the activities mentioned above. This percentage is down to 24% in Europe average .. and to 12% in Japan. This is a clear difference which is also telling on the internationalisation of SSIP and the specialisation that tends to go with it presently.

We then run data analysis on the indicators describing the various paths followed by the countries under view. The data used only concern European countries, the period is an average of the observations made in 1997 and 1998. Even if the development of venture capital is still at its beginning, its rapid growth in the late 90s, with a clear jump between 1996 and 1997 where the amount of new funds raised took off from 7,960 millions ECU in 1996 (4,398 in 1995) to 20,002 millions in 1997 (and 20,343 in 1998) is likely to be accompanied by large transitory changes in structures due to various lags, regarding both some forms and countries. This led us to retain an average of the most recent data 1997 and 1998.

To describe the structure of venture capital we retain the indicators previously mentioned, i.e. the type of investor (corporate, private, banks, pensions funds, ...), the origin of the investor ( almost half funds raised are from non domestic sources on average in Europe), the phase of the project (buy out represent half of the sums raised and start up 12%<sup>9</sup>), and the sector of investment (the high tech sector which includes communication, computer related, other electronics, bio-technology and medical/health related industries) amounts to 28% of the funds raised in 1998.

This data analysis concerns 12 European countries (EU 15 less Denmark, Portugal, Greece, Austria and Luxembourg, plus Switzerland and Norway.). The levels of new funds raised still differ largely between countries, it ranges from 8,959 millions ECU in the UK, 3,811 in France, 1,875 in Germany down to 222 in Switzerland and less than 100 millions ECU in most of the countries not included in the sample. This data analysis leads to the following typology of countries:

- In a first group we find The UK, Sweden and Finland,
- The second group associates France, Germany, the Netherlands, Italy and Spain, a group where the development of venture capital has been largely shouldered by the banks and insurance with more or less effective changes in the regulatory framework (as expected from public based systems of innovation).
- In a third group of countries Norway, Switzerland, Belgium and Ireland, e.g. countries with relatively small amounts of funds raised.

This typology seems much marked by the phase of development of venture capital in each country.

The rapid development of venture capital in Sweden and Finland, with a noticeable importance of projects in their early phase (and highly concentrated in high tech industries) accounts for their grouping with the UK, a country which totals half of the funds raised in Europe (but where projects are much less in high tech and

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<sup>9</sup> Even if seed and start up projects represent nearly a third of the total number of projects.

more in buy out phase than in start up ). Therefore, the development of venture capital led to building a chain of intermediaries. In countries starting late to develop this intermediation individual investors have helped to rapidly support an important batch of early phase projects. This can be done in a very inward manner like in Sweden and Finland (where most investment are of domestic sources) and still be largely influenced by some international norms and knowledge diffusion in high tech industries. Still other newcomers like Italy and Spain did not follow the same path. This “transfer” of financing intermediation effectively did not operate either in mature bank based systems like in France and in the Netherlands where the development of venture capital has relied on the responsiveness of the old structures as well as on the changes and incentives introduced in the regulatory framework (like in France where the government created specific bank based schemes ), well on line with what one could expect from public based systems of innovations.

Noticeable hybridisation are thus displayed by countries in the Scandinavian group as well as by countries in the Mediterranean group (Italy and Spain); where overall pressure to develop new forms of venture capital led them to adopt patterns close to those of other groups (the market based for the former, the public based for the latter). The development of venture capital also stressed the importance of non domestic sources of investment. The positions of countries differ markedly in that respect, with some countries strongly inward looking, some more outward oriented. The attractiveness of local venture capital for foreigners also depends on the maturity of the process, with the UK in a very privileged position in that respect due to the efficiency of its financial markets. Specific institutions in that respect do matter; and the existence of secondary markets as a mean of exit has been fuelling the development of venture capital. Meanwhile this common trend is more in accordance with market based systems and stressed a general shift of all systems in that direction. Finally the sector of investment also matters. There has been a widespread specialisation in the high tech industries and even in that range the role of ICT has been dominant as opposed to bio technologies. But clearly success in developing venture capital in one field does not ensure that it will adapt to another technology so easily. It is an important issue especially regarding the biotechnology.

Adaptations of systems to develop forms of venture capital have thus challenged the ability of systems to develop new types of markets and to monitor the development of new technologies. Market based and public based systems were in similar asymmetric positions to achieve such deed. The time horizons of the two changes are not the same either. It leaves rather open the final outcome in terms of successful adaptations of innovation systems.

A similar analysis has been run on the means of technology transfers using the CIS survey. It helped to portray how firms in a given countries are getting their information on innovation and to innovate. Again to find that countries follow similar paths in setting up means of financing risky innovation process and in accessing information help to precise our assumptions on complementarities regarding institutional changes .

#### 3.4.4. Challenges on SSIs: towards a phase II

SSIPs are faced with a central institutional change in the present phase of economic development centred around the forms of competition, influencing the ways in which economic transactions are informed and conducted. Such situation is common to all developed economies which in itself is an important feature of the contemporary transformation (which confirms its international nature).

The comparative statics analysis performed on the SSIP tells us that these systems, which had been identified in Amable et al. [1997], change very slowly, not only in terms of scientific and economic specialisation, but also in terms of institutional specificity. One should not expect too rapid changes in terms of industrial specialisation at the industry level considered in the course of this project. Competitiveness is a slow-building process and changes in relative positions take decades rather than years. Some intra-industry changes are nevertheless observable, which may not be minor from a macroeconomic point of view if one takes into account that the 'new economy' is based on the dynamism of a few key activities, mostly around ICT, but these changes do not radically alter the general pattern of specialisation of the countries under study.

It would however be misleading to conclude that nothing changes in SSIPs. The analysis of economic performance in connection to institutional specificity must avoid two mistakes: the first one is to consider that all countries are subject to world-wide trends that leave no room for variety among developed economies, and to apply a 'one size fits all' analysis to modern capitalist economies. There are various instances of this mistake, the most common takes the form of a recommendation to adopt the institutional features

characteristic of the country which enjoys the best macroeconomic performance at the time of the recommendation (France in the 1960s, Germany in the 1970s, Japan in the late 1980s, the US in the late 1990s,...). Another variant is to isolate a key mechanism of evolution of modern capitalist economies affecting all countries, for instance financial liberalisation. The next step is to conclude from the forms that this evolution takes in one country (usually the country which has the best macroeconomic performance at the time) that all modern economies will (or should, depending on how normative one wants to be) take the same path, regardless of the structure of the national economies concerned. This is in a way an evolutionary argument. There is a new general evolution principle for developed economies to which countries should adapt or die.

The second mistake is to consider that variety is so significant that the evolutions that affect all economies at the same time are of secondary importance compared to the structural inertia that characterises the various types of capitalism. Technological revolutions may come and go, the hierarchy of institutional forms may be altered, internationalisation may take different forms, Germany will always be Germany, etc.

In order to overcome this dilemma, one must explicitly take into account two dimensions for change. The first dimension is the global one, that of trends and evolutions which concern the world economy and all countries at the same time. One includes in these global trends all the changes we have gathered under the term of 'internationalisation' and which refer to the new patterns of technology transfers, exchange of services, the evolutions of the financial systems... These changes manifest themselves by a change in the hierarchy of driving institutional forms.<sup>10</sup> The forms of competition exert a prominent influence on the way the complementarity of institutions in each SSIP or country is organised so as to define a coherent and viable system. To recall, the dominant form of golden-age capitalism was the wage-labour nexus.

The second dimension is that of the internal logic of each SSIP, a logic we have analysed as institutional complementarity. How does this complementarity evolve under the influence of its own components. In other words, does the dynamics of the different institutions whose complementarity constitute the systems lead to a destabilisation of the system itself. The fact that a static complementarity exists at one given moment does not imply that all institutions are going to stay put until the end of time.

One simple way of taking explicitly into account both dimensions of change would be to consider evolutions affecting the SSIP as the result of both types of evolution: changes which are specific to each SSIP, as consequences of each SSIP's own dynamics, and changes which concern all SSIP. One would for instance consider that SSIP do change radically overnight, but slowly evolve, with incremental changes at the margin, under the influence of factors pertaining to the two dimensions referred to above. This would explain why diversity among capitalist economies might be preserved in spite of global changes which seem to affect all economies in the same way at the same time. This position is not without empirical support, as proved by the analyses presented above.

Another way to look at the problem would be to differentiate among the factors of evolution belonging to either dimension, i.e. the SSIP-specific and the global changes, and isolate changes which could be considered as radical from those which are more incremental in nature. Intuitively, one suspects that if some changes have far-ranging consequences in either dimension, the idea that systems evolve incrementally at the margin may be wrong. But the theory of institutional complementarity tells us more than that. In order to have far-ranging consequences, changes do not have to be 'radical'. Even a seemingly minor change can threaten the pattern of complementarity and induce a change in nature for the whole system.

The hypotheses we took were that changes in forms of competition could produce some seemingly minor changes in the concerned areas, which could threaten the stability of some SSIP. Among the transformations of the forms of competition, one can consider more specifically all aspects of internationalisation and changes in financial systems.

The general change in the forms of competition has pressed for a more rapid flow of innovations and therefore for a more dynamic, risk taking behaviour regarding the financing of innovations. This common drive for a "venture capital" was given very different answers according to the type of financial system and to the other characteristics of the SSIP. Analysing the diversity and the rapidity of these answers gives a good illustration of the dynamics of institutional change. Our analysis stressed the dominant positions of some

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<sup>10</sup> See Amable [2000].

early which reacted promptly to the need, it shows how some traditional banking has been able to adapt its structures or how some public based system also showed adaptive capability.

A parallel characterisation of the SSIP could have been tracked down following how countries adapted to the globalisation of some part of scientific knowledge (see Archibuggi and Michie, 1997) produced by a new relationship between science and economic activities (see Gibbons 1995, Veltz, 2000) and by a development of the personal and electronic relations between international communities of scientists. The adaptation to such global changes in technology transfers could have taken various routes, from reorienting the educational systems (which takes time) to importing qualified manpower and know how, either by means of brain drain (an highly specific mode of adaptation which imply a good attractiveness of the country under view ) or by means of international organisations such as MNEs. The development of large metropolises could also facilitate this dissemination of knowledge. In that respect we took a functionalist perspective (how some kind of specific challenge has been faced in one country or other) but there are complementary perspectives that have been followed in the research project that focus on the means used to achieve these various goals.

The role of MNEs for instance can be seen as evolving during the present phase of internationalisation. Regarding both finance and R&D they seem to be less attached to their home countries. In such second phase MNEs would be important actors in setting some new forms of international organisations. The distinction between host and home countries in that respect would be significantly modified.

Similarly changes in the economic geography of the economies under view tend to stress a new balance between local and central governance of economic activities. This new balance is bound to affect SSIP. The change is the SSIP in the new context will reflect this new balance. This new geography brings also the question of agglomeration effects in large metropolis.

As the evidence presented in the previous sections show, some SSIP have been more robust than others. Considering the evolutions concerned, it is not surprising that the market-based SSIP has maintained its stability, accentuating its characteristics. But the current vogue of market mechanisms should not conceal the fact that among the countries belonging to this SSIP, only the US enjoy a clearly outstanding macroeconomic performance (see for instance Figure II-1 above). In other words, and this is not surprising, there is no univocal link between a certain institutional architecture and certain macroeconomic performance.

The meso-corporatist SSIP has kept most of its specificities, the only change with respect to the previous decade concerning the macroeconomic evolution. The SSIP which is characteristic of South-East Asia has experienced its worst decade since the end of the second world war. Countries specialised in mass-production ranging from average (Korea) to very high (Japan) quality have found it difficult to adapt not so much to a new type of product innovation (less incremental) than to the new phase of financial liberalisation. This last factor threatened the whole structure which had supported their tremendous economic success for several decades.

Changes in the pattern of internationalisation has had more influence on the other two SSIP. Finland and Sweden, the more technology-intensive countries of the social-democratic SSIP, seem to follow separate paths from Norway and Denmark. Norway seems to some extent closer to the market-based SSIP whereas Denmark has some common characteristics with the public SSIP.

This last SSIP appears once again the less homogeneous and the less stable of all systems. Both internationalisation and financial liberalisation have subjected the countries of this system to divergent evolutions. Italy shares important common characteristics with the Mediterranean countries, as far as foreign trade, technology and specialisation are concerned. On the other hand, Germany and the Netherlands are closer to some countries of the Social-democratic SSIP than France or Belgium. These similarities or dissimilarities already existed at the time of the analysis performed in Amable et al. [1997], but it appears that no convergence has been underway since.

The evolutions concerning the financial system and corporate governance have also questioned the homogeneity of this SSIP. The dominant evolution was a weakening of the traditional bank-based systems and a growing importance of disintermediated finance in every country. But this general trend has not had the same consequences in every country. The most solid bank-based systems (Germany, ...) have been more resistant to change than the less solid ones (France, Italy, Belgium), where the rise of market finance and the

decline of not very profitable banks have quite logically co-evolved. This has had consequences for corporate governance and, one suspects, the type of investment that firms will undertake.

Questions concerning Europe are then centred on the heterogeneity of countries in the EU. This heterogeneity is not a problem *per se*, but with respect to a common European technology and industrial policy. Considering the various SSIP European countries belong to, it is obvious that European policies regarding competition, deregulation, privatisation, etc. are going to have different consequences on the dynamics of countries according to whether they are part of the market-based SSIP, the social-democratic SSIP or the public SSIP. As the analysis already shows, the latter system appears the more fragile of all, all the more that the countries belonging to this system have mostly had mediocre economic performance during the 1990s. One may argue that subject to policies that seem to steer countries toward an extension of market-based mechanisms, the fragility of the public SSIP will imply a radical change for countries belonging to this group. Consequences for innovation and technology may be far-ranging since the specific form of innovation favoured by this SSIP (programs, rather radical technological advances,...) may be endangered.

Another aspect concerns the regional dimension of technology. The results presented above do not indicate a radical autonomy of the regions from their home countries in their economic and technological development. The 'technological geography' of regions is of course more complex than that of countries, but what comes out the analysis does not contradict the prevalence of 'macro', national-level institutions over more local dynamics. This does not mean that regions have no development autonomy, but that this development takes place under the influence of the macro-level institutions that define the SSIP. Therefore, the effectiveness of regional policy will crucially depend on the institutional features of the countries the regions belong to.

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## 4. Conclusions and policy implications

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### 4.1. Conclusions

#### 4.1.1. Introduction: the problematic of the present phase of internationalisation and its effects on the complex architecture of the SSIPs

The present phase of internationalisation is mainly characterised by the dense nature of the linkages that have been organised at international levels. Its unprecedented nature does not rely so much on the fact that flows of goods or services or financial transactions would have reached in relation with GDP levels never experienced before. More innovative is the far ranging nature of what is nowadays transacted internationally. Economic agents have already set up or can dispose of vast networks or links of international relations. They can therefore define their strategies at an international level more than ever.

In this broad web of relationships and tangible and intangible transactions, the specific setting of institutions first considered as national systems of innovation (NSI), soon expanded in the form of social systems of innovation and production (SSIP) are bound to be affected and transformed accordingly.

Basic assumptions could be that these systems erode and evolve towards one unique form of institutional arrangements.

In a more structuralist approach one would say that the very structure of SSIP in the context of a process of specifically defined internationalisation would be likely to determine a set of specific reactions where the systems can become more or less effective and would at some point be forced to adapt.

We shall try to follow this last path building up on the theory of institutional change that has been developed in Amable and Petit (1999), stressing the importance of such relationships between institutions such as complementarities and hierarchy in shaping the patterns of change.

Our approach will be much more centred on the dynamics of the various institutional configurations at work in what is called systems of innovation. We retained a broad definition of these systems and therefore consider broad range of institutions and assess their likely dynamics under the constraint of internationalisation. We reckon from the start that the dynamics of the sets of institutions are strongly determined by the various complementarities that link together in various ways subsets of institutions. At some previous period of “golden capitalism” these trends were much oriented towards changes in the wage-labour nexus. In the present period we retained that these trends are more centred around changes in the “forms of competition”, i.e. in the fabric of institutions that govern in each country how markets operate and how economic agents in general tend to set up arrangements of all kinds (to include the transactions which are not market transactions as such but do affect the functioning of markets as the actions of NGOs, professional or cultural associations, etc....).

We shall thus proceed afterwards in assessing the directions of change of the various SSIP and how it may affect their working and their future. But first is it not paradoxical to look at the changes in institutional configurations that precisely stressed “local effects” in a world of more and more opened economies?

#### *A paradox?*

As we stressed it may seem paradoxical that the notion of national systems of innovations (NSI) has been developed (among others by Nelson et alii [1992], Edquist, Lundvall,...) precisely at a time, the 1990s, when countries appeared to become more structurally internationalised.

The fact is that this stress on national traits came precisely at a time when differences in trajectories of national economies, faced with apparently similar external challenges, seemed to be an essential feature of this broad common process of internationalisation. The NSI approach has thus to be replaced from the start in a dynamic context of common external challenges.

In the first place these national systems have structures of their own, with complementarities between their parts, which condition their dynamics. Comprehensive approach of the institutional background of national systems as claimed in the works on SSIP (social systems of innovation and production) should thus insist on the importance of the whole internal institutional context in the performances of countries. In particular the working of these systems will be differently affected according to the forms that the external challenges can take along time.

In the second place this common external challenge should be especially qualified respectively to the inner dynamics of institutions. It should thus be related with the precise dynamics impulsed by the prevailing area of institutional changes, namely in the current period the forms of competition (which constitute a kind of hierarchy between institutional areas according to our approach of institutional change).

Given these specifications, we may say moreover that it would be effectively in contradiction with the spirit of the approach to assume that SSIP are simply dissolving or converging in the process of internationalisation. The evolutions are more complex and combine common trends and adverse or diverse reactions.

How then to assess this process of “internationalisation and technological change” and its effects on the complex architecture of SSIPs ?

Our conclusions on such an assessment are presented along four levels of analysis:

- a conceptual level;
- a SSIP macro-level;
- a regional level;
- a level of the multinational firms.
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#### 4.1.2. Conclusions at conceptual level

We argue that the notion of system of innovation and production makes sense only when enlightened by a theory of institutional complementarities. In fact, every systemic view of the modern economies has implicitly or explicitly a theory of complementarity between activities.

A zero-level of complementarity can be associated with a selection of institutions directly induced by a selection of connected activities. The connection between activities may seem a straightforward notion as it refers to activities effectively directly interacting in some transactions. The institutions “monitoring” these activities appear thus ‘de facto’ connected, which may constitute a notion of ‘weak’ complementarity. This notion is used in NSI approaches, although not necessarily claimed for. The NSI itself is then an extension of the activities (and institutions) connected to the technology field.

A first genuine and specific notion of institutional complementarity corresponds to the case where two or several institutions may have a joint effect on, say, macroeconomic performance or more generally on the shape of the growth trajectory. Such interrelations may occur in different ways. The existence of one institution can thus make the others more efficient with respect to the system taken as a whole. Each institution or mode of organisation defines a set of constraints, incentives and possibilities that will determine agents’ strategies. The point is that the final impact of one institution on some economic issues is reinforced when the other complementary institution is present. In other words, one institution, or one system if there is an isomorphism between systems (finance, education, etc) and institutions, functions all the more efficiently when the other institution is present.

This notion of complementarity, in its true forms is fundamental in asserting the coherence as well as the pattern of evolution of an economic system. The ‘coherence’ of a system is then the ‘macro’ expression of the complementarity between specific institutional forms and the outcome in terms of economic performance (growth, employment,...). It differs across systems according to the type of complementarity.

One does not consider the isolated influence of one institution on a specific area of the economy (technology for instance), but the joint effect of a series of institutions and modes of organisation on the whole economy. Different structures of institutions may thus ‘perform’ roughly the same -in terms of an economy’s growth rate for instance- in spite of having separate components which may look very different when compared to one another because the relative efficiency of an institutional structure depends on the way the different

components operate together. Just as one particular institution defines a set of constraints, possibilities and incentives for individual agents, several institutions will define a set of interrelated incentives which are going to jointly influence the individual agent's behaviour. It is therefore logical to take into account the structure formed by several institutional arrangements rather than isolated institutions, with the hypothesis that the institutional structure defines the coherence of a 'national model', a historical phase of development, a system of production, etc. To put it in a different way, the various institutions, patterns of organisation, rules, norms, conventions... of an economy are not a more or less random collection of non-market arrangements. The presence of a particular institution, in a particular form, may or may not be compatible with the presence of another. The conditions for its existence and the relative efficiency of an institution - according to economic criteria- must then be determined by taking into account a large set of institutional arrangement, not just one institution alone.

The basic hypothesis is therefore that, several institutions -in the broad sense- taken together reinforce each other so that they form a coherent and stable but not everlasting structure. Sticking to a macro point of view, this structure shapes the growth trajectory or the general features of an economy. The aggregate coherence given by a set of institutions is defined by the complementary character of institutions. The concept of complementary institutions is based on multilateral reinforcement mechanisms between institutional arrangements: each one, by its existence, permits or facilitates the existence of the others. Sticking to the static equilibrium defined by a particular structure of institutions, the constraints and possibilities defined by a given institution favour other institutions' functioning. Complementary institutions make one another more or less efficient according to their respective characteristics.

This complementary character is fundamental for defining the coherence as well as the pattern of evolution of an economic system. The 'coherence' of a given system -a 'national' model for instance, defined as the set of interrelated national institutions- is then the expression of the complementarity between specific institutional arrangements and the outcome in terms of economic performance (growth, employment,...)

The notion of institutional complementarities links together different institutions and modes of organisation in a certain architecture. A notion of hierarchy of institutions insists on the relative importance of one or a few institutions for the architecture as such. In a static perspective, hierarchical relationships define a link between institutions and should therefore be explored starting with the different kinds of complementarities that we have distinguished. Still it is difficult to assess an asymmetry in the two kinds of complementarity relationships that we defined above.

One needs to take a more dynamic perspective in order to introduce asymmetries between institutions. The asymmetry could be that one institution changes when the other does not. A more genuine hierarchical relationship would stem from the fact that changes not only occur in one institution but do induce changes in other institutions. The changes may concern the conditions and rules of application of an institution or the way in which it affects economic issues. Transformations of specific institutions may be difficult to conceive and to follow comparatively. Such dynamics may be more relevant when applied to sub sets of "coherent" institutions.

The above exposed analysis of the relationships that structure the fabric of national institutions leads to some important implications. First the role of one or a few institutions cannot be isolated from a context, if only of other institutions. The way in which institutions influence behaviour in one field may well relate to the existence of complementary institutions. These complementarities can take place at various levels.

Such seems to be the case regarding the innovation capability of a country. The central role of this capability in determining the competitiveness of countries helps to suggest that institutions supporting the dynamics of innovation can somehow be copied and transferred. Our argument stresses that such reverse engineering could be very misleading if one did not take into account the various complementarities conditioning both the implementation and the impact of institutions.

Investigating the structure of the national fabric of institutions may help to reduce the problem posed by the complexity of the laws of institutional change. It can lead to some pragmatic principles which would help to some broad targeting of objectives.

#### 4.1.3. Conclusions at SSIP macro-level

We have update and extended a previous taxonomy for social systems of innovation and production and characterise their dynamics with the following objective:

1. to survey a large number of possible SSIP parameters and select them in terms of the availability and quality of data,
  2. to establish a typology of Social Systems of Innovation and Production (SSIP) and characterise different types, thus re-visiting the previous taxonomy of social systems of innovation established by Boyer, Barré, Amable [1997],
  3. to provide a dynamic perspective for these Social Systems of Innovation and Production over the period 1986 - 96,
- to deepen the analysis by explaining the overall structure, typology and dynamics by the role of various sub-systems.

*The conclusions of results of the analysis for year 1996 and of the comparison with results from Amable, Barré, Boyer (1997) are:*

##### ***1. the SSIP models and types have a robust definition***

The comparison between the results from Amable, Barré, Boyer dealing with 1992 data and from this study show a relative stability of the SSIP types over time and over the choice of variables, which leads us to consider that the identification and characterisation of the SSIP types is quite robust. Fundamentally, this is due to the existence of socio-political compromises and complementarity among sub-systems which do not allow for quick changes in the structural features embodied in a SSIP type.

##### ***2. there is a good stability in the relationship between countries and SSIP model***

The countries are quite stable in their SSIP type between analysis with 1992 and 1996 data. The fact that S&T capabilities are accumulated over time, that technological trajectories are path dependent, that institutional forms are strongly resilient do explain this situation.

##### ***3. some structural evolutions or instabilities can be conjectured***

The social democrat and the meso-corporatist models are still identifiable in our analysis, but they come close to variants of the public institution based model. This may be due to evolutions of those models, or to the fact that they differentiate themselves by parameters not taken into account in the analysis.

##### ***4. the EU member states share key features in their SSIP, allowing us to define a broadly defined EU-Area SSIP model, having much to do with the public institution based model***

The EU member states SSIP share almost all the parameters of labour market – social protection sub-system, as well as a relatively evenly distributed income and an important role of government services in GDP. They also share :

- a relatively important role of industry in economic activity,
- a high proportion of national industrial RD in automobile, chemistry, equipment goods,
- a scientific specialisation in physics and chemistry.

In brief, EU-Area SSIP are all characterised by significant redistributive functions aimed at social objectives and public services, particularly in relationship with the labour market. They are also all characterised by the importance of ‘classical’ industrial sectors (such as automobile, chemistry, equipment goods) and the intensity of their innovation activities in those sectors.

##### ***5. nevertheless, the EU-Area SSIP model has variants related to substantial differences***

EU member states SSIP differ on GDP per capita and rate of unemployment, on all parameters of sub-system volume and funding of RD activities, and on most parameters of sub-system education activities.

They also differ in their :

- proportion of agriculture and of electronics sector in GDP,
- proportion of national RD in labour intensive sectors,
- level of technological specialisation in electronics, as opposed to household consumption goods
- level of specialisation in biology and medical research, on one side, in engineering and mathematics, on the other.

*Such differences are important enough to raise questions on the dynamics of the variants, as well as the conditions of a European research area.*

***1. there is no overall convergence of the types but a combination of common trends and specific divergence elements***

***2. the common trends: the emergence of the knowledge based society***

a) All types exhibit the following evolutions:

- higher RD expenditure both public and private, increased scientific and technological activity (sub-system 1 – volume and funding of RD activities), particularly in biology and information based areas (sub-system 2 and 4 – scientific and technological activities profile),
- higher public expenditure on education, increasing proportion of upper secondary level graduates, as well as increasing higher education enrolment (sub-system 7 - education),
- increasing importance of business services in economic activity (sub-system 5 – economic activities profile),
- higher GDP per capita (sub-system 8 – macro-economic and social performances.)

b) This overall common evolution concerns:

- almost all the parameters of sub-system 1 (volume and funding of RD activities) and of sub-system 7 (education),
- one or two parameters of the profiles / specialisation sub-systems (scientific, technological and economic activities profiles) (sub-systems 2, 4 and 7),
- one parameter of sub-system 8 – macro-economic and social performances (higher GDP per capita.)

These dynamics, which cuts across most of the sub-systems, can be summarised as reflecting the emergence of the knowledge based society.

***3. on the whole, these common trends are neutral with respect to the divergence – convergence problematic***

These common dynamics linked to the knowledge society develop in a parallel way and at a broadly similar speed among types. They do not result in either convergence or divergence, and they are somehow neutral in this respect.

***4. the most important divergence element is related to the labour market and social protection sub-system and to the income equality problematic***

Non-EU SSIP types evolve on the whole towards more income inequality, less social protection and less labour regulation, in sharp contrast with the evolution of EU-SSIP types.

This concerns most of the parameters of sub-system 6 (labour market and social protection), and one parameter of sub-system 8 – macro-economic and social performances (income distribution).

***5. this divergence element, on the whole, strongly discriminates EU-Area SSIP types from the others***

Such discrimination occurs in a double way :

- all EU-SSIP type share, on the whole, relatively high figures on the parameters related to the labour market and social protection sub-system and to the income equality problematic. Such parameters are one of the basis of the existence of what we have called a EU-Area SSIP broadly defined model (the other basis has to do with both the relative importance of industry as a whole, of certain mature sectors of industry in particular and their related innovation capabilities),
- it appears that precisely on those parameters, EU-types evolve in the same way, as opposed the non-EU types. In other words, the dynamics at play tends to reinforce the specificity and reality of the EU-Area SSIP broadly defined model.

***6. important nuances must be brought to this picture***

There are questions on some aspects of the evolution of the EU-Mediterranean type, which has a questionable record regarding the labour market and social protection sub-system. At least an evolution which differs from other EU-types, and very much similar to the evolution of the Anglo-Saxon type.

The EU-Nordic type exhibits some specific trends, mostly due to its performance in the electronic industry. There are hints that such performance has impacts on the SSIP and its dynamics. But on the whole, it is very much coherent with the EU-types dynamics.

The position and dynamics of the UK raises questions: this country is clearly positioned in the Anglo-Saxon type and its dynamics is clearly coherent with that type, considered as non-EU, in other words diverging from EU-SSIP types.

Finally, the comparative study on technological progress, structural change and productivity growth focuses on the impact of specialisation and structural changes on productivity growth in manufacturing, using a sample of 39 countries and 24 industries between 1973 and 1990 and shows that while structural change on average has not been conducive to productivity growth, countries that have managed to increase their presence in the technologically most progressive industry of this period (electronics) have experienced higher productivity growth than other countries.

The main difference concerns the role played by new technologies in generating structural change. In the first half of the 20th century, growth of output, productivity and employment were strongly correlated. Employment in industries based on new technologies (such as electricity and synthetic materials) expanded rapidly at the expense of more traditional industries, implying an important role for structural change in explaining overall productivity growth. More recently this relationship between output, productivity and employment has become more blurred. New technology, in this case the electronics revolution, has expanded productivity at a very rapid rate, particularly in the electrical machinery industry, but without a similarly large increase in the share of that industry in total employment. In fact, the industries that increased their role in total employment most substantially were generally traditional industries – mostly geared towards private consumption - with average to low productivity growth. Hence, in recent decades, new technology has not been linked with structural changes in demand, output and employment in the same way as before. This explains why structural change - in a pure accounting sense - was more important for productivity growth previously than it appears to have been more recently (at least up to 1990).

However, this does not mean that the electronics revolution - or the structural changes associated with it - have not been important for overall productivity growth in the period under study here. First, the electrical machinery industry (which is the industry most intimately related to the electronics revolution) has experienced much higher productivity growth than any other industry, implying a growth bonus for countries with a superior performance in this industry. Second, there have been important spillovers to productivity growth in other industries, and available research indicates that these have been stronger at the local or national level than globally. Hence, the results presented in this paper suggest that countries that during the period under study here managed to establish themselves firmly in the electronics industry got a sizeable growth bonus from these investments.

This being said, it seems appropriate to issue a warning regarding the possible implications of these findings. First, leading technologies – and the industries most affected - change through time, and so do the conditions for entry and the rewards from it. Thus, the relevant policy conclusion to draw from this is not that every country should move into production of electronics as fast as possible. Rather, the lesson is that there may be important potential gains to overall growth and – possibly – welfare from successful entry in technologically progressive industries that should be taken into account when designing policy. Second, little is said here about what the conditions for such entry were during the period under study or – of even greater importance for policy - are likely to be in the future. Without a clear understanding of these conditions - and how they relate to existing national assets and capabilities - it becomes difficult to discuss policy in a meaningful way. Arguably, these questions deserve a high rank on the future research agenda in this area.

#### 4.1.4. Conclusions at regional level

The question of geographic coincidence of science-technology activities was addressed at the European level, using a breakdown into 450 regions. Geographic coincidence is a necessary condition for emergence of local spillovers or other S&T transfers.

A typological work was carried out, first by ranking regions on S&T output and per capita output, and distinguishing for convenience five groups, from the leaders to the very weak regions; then additional characteristics were depicted, first of all the general orientation towards science, technology, or economic

activities. The leading class concentrates almost two thirds of European S&T output - a confirmation of previous findings about the degree of concentration of science and technology in Europe – and a majority of leading regions displays a rather balanced activity between science and technology. The leading class also exhibits the best thematic concordance between science specialisation and technology specialisation, and a stronger representation of "large applicants" in patent production. As far as a geographic potential of localised spillovers / transfers is concerned, the regions belonging to the leading class can mobilise masses of knowledge in both areas, appropriate knowledge and academic knowledge, giving room for creative exchanges between science and technology.

Nevertheless, other classes cannot be neglected, and the question remains of the regularity of the coincidence between S&T over a wide range of regions "sizes". An insight in geographic co-location between science, technology and other variables such as GDP and population leads to the conclusion that technology-science correlation at the European level is quite noticeable, but much inferior to technology-GDP one. This is also true for most individual countries. The empirical linkage of S&T is interesting on its own, to assess the gross potential of exchanges between S&T currently available, but says nothing about the underlying factors, especially eco-demographic substrate, without talking of the mechanisms.

The next part of the study precisely aimed at isolating a possible specific science-technology connection, independently of other determinations. At what extent the spatial distribution of technology can be explained by science vs. economic substrate? Using multiple regressions, we found that, considering all regions together at the European level, the specific effect of science is at the limit of statistical significance. GDP is a significantly better predictor of patents geographic distribution, in any form (all patents, large applicants' patents, not-home based patents...). Again, at the individual country level, this result is prevalent with few exceptions.

However, all these correlations studies were "global", taking all regions regardless of their specific vocation. Investigating more precisely the S and T relationship, we found that the collection of regions could be considered as a mix of two sets to be defined after the typology above, the "scientific" family exhibiting a science orientation (and possibly others), and conversely the "technological" family. The two families are overlapping in the area of leading regions, with balanced vocations, but tend to split elsewhere in a bimodal distribution (the quasi-zero regions should be excluded). When treating separately the two families, the effect of science becomes significant. For the science family, a predictive model will show a quite high elasticity of technological output as a function of the scientific output.

Those remarks are still reinforced in the sectoral approach. Introducing a "thematic concordance" measure in all-fields studies is sometimes helpful to make clearer the role of science distribution. Restricting to a technological area with high-technology involvement, and corresponding scientific specialities, gives evidence of the autonomous character of the geographic linkage science-technology.

In terms of geographic regularities, the coincidence between "large applicants" patents and science is rather inferior than for "all patents", with very few exceptions for individual countries. There is a slight indication that "not home-based" are somewhat more connected to science than "large applicants' patents" as a whole. If no general geographic rationale tends to tally large applicants' presence and academic location, the concentration of both activities in large metropolitan areas however creates a large theoretical potential of exchanges. In secondary centres the criterion of academic presence seems less relevant for MNEs' attraction.

*Limitations of the study are of several kinds:*

Regional data are still imperfect for a decade's retrospect, and we had to stick to a static point of view. A longitudinal study with more extensive retrospect than in the previous OST studies would be necessary to address convergence issues for science and technology production, and also (see below), to provide an insight into dynamic relations.

The analysis was limited to a particular breakdown, and did not cope with inter-regional similarities (spatial correlations between nearby regions, for example; distinction between laggards close to large concentrations and isolated ones...). Homogeneous zones in terms of output and vocation, could be found covering larger regional areas, for instance in Germany and northern Europe. Trans-frontier regions are also worth further examinations.

The network dimension would also deserve an extensive study, in order to compare local logic (for example intra-regional co-publications, nearby regions collaboration) and global logic (co-publications within archipelagos of large cities, inside or outside the country). On the technology side, co-patenting is however more difficult to interpret.

A more systematic approach of science-technology in strategic areas would also be of value. The evidence we found that the geographic linkage between production of patents and publications is tighter in a high-technology field, needs to be more extensively tested. This is a strong incentive to extend sectoral studies.

More fundamentally, the study was limited to the geographic coincidences. As strong as they might be (and there are usually moderate), spatial coincidences do not prove the reality of spillovers or other exchanges. The geographic patterns may be interpreted both as a result and a cause of S&T interactions. These interactions can rely on many mechanisms, largely studied in literature: improvement of performance through better communication, availability and migration of skilled manpower (students, scientists), attraction of enterprises, creation of enterprises and other complex co-development patterns of university and industry research.

These results and their limitations are strong incentives to extend the research in these directions.

To conclude, Europe of science and technology displays a large variety of situations. Heterogeneity is the rule. The diversity of national innovation systems, and of infrastructures rooted in national economy history, has coined contrasting geographic patterns of science and technology location. The variety of regional orientations is also quite large. The typology we proposed allows a precise profiling of regions from this point of view. The "national effect" can be indirectly seen through the typology, with striking contrasts between countries as to their representation among classes of the main sequence, and categories of S,T,E orientations. Results are by and large consistent with OST-CEPREMAP's countries typologies.

The concentration of S&T outputs and resources in a minority of regions in Europe, probably due, in part, to virtuous circles of endogenous mechanisms, is a reality. In this "elite" of regions, powerful both in science and technology, both in S&T production and density, both in SMEs and MNEs patenting activity, the geographic conditions for large amounts of S&T localised transfers are fulfilled.

If we don't focus on the leading core but on the wide scope of regions with various S&T sizes, the geographic patterns appear to be moderately favourable. The technological activity tend to make proportion with the academic one, if only because of the demographic and economic background, but in a pretty loose way. A divergence in the vocations of the regions, science or technology-oriented, appears as soon as we quit the "elite" class, which also means that the overall potential of exchanges can be hindered. When looking separately at the "scientific" and the "technological" family of regions, geography of science becomes a significant predictor of geography of technology, less than GDP when all fields are considered, but more than GDP when the focus is set on a high-technology field.

This suggests that in the "scientific" family of regions - not a majority in Europe - mechanisms exist that proportion the technological development and the scientific development, but within paths with unbalanced activities – in contrast with the situation prevailing in the leading class of regions. It is reasonable to assume that at the regional level – but this cannot be demonstrated solely from our findings – fostering academic resources will tend to develop the technological power along this trajectory. On the other hand, further studies would be necessary to assess whether variations of the technological potential of regions belonging the "technological" family can affect the academic potential, perhaps through various forms of funding within an appropriate institutional framework. Another point of importance for S&T policy is the case of quasi double-zero S&T activity, that would be worth a special attention. Is there a slight chance that mechanisms triggering a catch-up process at reasonable costs, could be put at work?

#### 4.1.5. Conclusions at the level of the multinational firms

The study at the level of the multinational firms has established that multinational companies play a key role in national systems of innovation. Their share of total spending on R&D in most countries is so significant that a radical change of these companies' strategies will be felt throughout the system. The intensity of their

interaction with other parts of the system varies from country to country, but inter-firm relations as well as collaborations with the public research infrastructure is eminent. In this sense the actions of multinational should be a prime policy concern for both small and large countries.

The internationalisation process of multinationals and in particular of core companies that were bound to the national home market (for instance due to regulation) is progressing with leaps and bounces. The pace varies between sectors and sometimes firms even lower their internationalisation. Likewise, R&D gets re-centralised from time to time. In case this happens (for instance with Philips) firms tend to choose for the well-established and well-known home-base. Therefore **history matters**. MNEs value the networks, common culture, familiarity with labour practices, and linkages that have been created over the years in their home country.

As a consequence **nationality still matters**. Firm nationality - and thus the distinction between home and host system of innovation/country - still matters in at least three ways:

- In most countries the bulk of the R&D expenditures is still performed by national (home-based) firms. The UK seems to become an exception.
- The internationalisation patterns of innovation (in both patenting and R&D organisation) often reveal more distinct national than sectoral or size-specific characteristics. This corroborates the idea that the home-base influences the properties of the internationalisation strategies of MNEs in quite distinct manners (Cf. Whitley, van Tulder/Ruigrok). As a consequence, interactive innovation with a subsidiary of a Japanese, German or American company reveals also distinct characteristics. Patenting strategies for instance reveal varying degrees of centralisation and control. National styles of multinational companies exist.
- There are still clear differences in the R&D strategies (including R&D intensity and the nature of the R&D function) of 'home' and 'host' firms inside national innovation systems. An exception seems to be the Netherlands, where host multinationals seem to share comparable characteristics as most of the home multinationals.

Due to the latter observation, it is safe to conclude that **ownership and thus the distinction between home and host company still matter**. As soon as an important national player gets taken over by a foreign partner they become part of the strategic planning of exercises of other firms. This can increase the function and position of the local R&D department. But this only seems to happen in case the surrounding NSI is strong and dynamic (and therefore probably also contains a large number of other innovative players). In case the surrounding NSI is relatively weak the position of the R&D department of the acquired firm tends to become jeopardised. There is anecdotal evidence for this, but not yet systematic research.

#### **Size still matters.**

R&D is a small numbers' game, the dynamism of interactive innovation consequently often depends on the interaction of only few big players. Critical mass is important for firms to locate activities somewhere. Firms themselves require critical mass, partly also because governments have lowered their relative expenditures in R&D. Weakly developed NSIs therefore will never attract really high-end parts of the R&D organisation of host-based multinationals.

#### **International co-ordination is still largely lacking.**

International innovation systems are developing, thereby overarching national boundaries. But this process evolves at a relatively slow pace, due for instance to the limited progress in setting up really supra-national institutions:

- The multinational firm itself can be considered to be a supra-national innovation system (perhaps even an institution), co-ordinating innovation over a variety of countries and aimed at its own (supranational) business aims. But with strong ties to its home-base and therefore not really supra-national in nature.
- Slowly a system of world-wide patenting is developing in which on the basis of intellectual property right (WIPO) rules more and more firms are applying for harmonised patents. In practice, however, distinct patenting strategies can be observed, while at most the first steps towards a macro-regional dynamism (in Europe) in patenting can be witnessed.

The prevalence of national patterns, combined with the lack of real supra-national institution should make the fear of policy makers that their home-based firms could become completely 'footloose' not justified. Investments in R&D abroad are mostly additions to home-based R&D activities and not a replacement.

Nevertheless, MNEs are very well aware of the political sensitivity of this issue and therefore cautious to reveal their long term plans for shifting the geographical focal points of their R&D activities.

**MNEs still value proximity in collaborating with other parts of the innovation system.**

The qualitative part of our study showed that MNEs value to work with research organisations in their region or in not too far distance from their headquarters. However there were some clear trends coming out this part of the research that might weaken this current approach in the future:

- The quality of research in the home country has to be high enough to at least keep up with international state-of-the art. Some concern was expressed relating to the deterioration of the science base and the lack of highly qualified staff to perform this.
- MNEs are finding their ways to research excellence regardless where in the world. Although the headquarters of corporate research are not being relocated, specialised research centres in particular technologies are established in those areas that can offer the skills and knowledge. Examples are the US West Coast, areas in South-East Asia (Taiwan, Singapore, China), India for information technology. MNEs in the more mature sectors such as chemicals and automotive will be less prone to these global shifts since the core technologies have already settled in specific areas. Particularly in the newer technology areas, the regional specialisation patterns are still moving and therefore R&D strategists with MNEs will keep an open mind to where to locate specialised research units.
- MNEs stated that their collaboration with the public research infrastructure is oriented more towards fundamental-strategic research than towards applied problem solving research. Applied research, particularly when it is closely connected to the companies' core business is done in-house and not shared with external parties. It is in fundamental research where MNEs seek complementary expertise, particularly to stay informed about a range of technological options for the future. On the other hand we see a trend in Europe that universities are encouraged to move towards more applied and market – near research and to play a more active role in helping industry to innovate. From the perspective of MNEs this trend would make the public infrastructure less interesting since the complementarity with their own knowledge base is diminishing. The policy conclusion is that in order to embed MNEs in the national system of innovation, investments in basic research are an indispensable element of a healthy system. This does not imply a move back towards mono-disciplinary, blue sky research, but interdisciplinary fundamental research that fits the 'Mode II' model.
- The main bottleneck from the perspective of MNEs, is the cultural gap between the universities and the logic of their business enterprise. Particularly in Germany, and to a lesser extent in the Netherlands and UK managers of MNEs perceive the universities as organisations that stand too far away from the needs of commercial enterprises. There is still a reluctance to perform research with a commercial focus, the bureaucratic regulations do not allow an efficient collaboration and often senior staff are not willing or allowed to collaborate in projects. From the perspectives of multinationals the research-industry interfaces are not functioning well enough, despite many policy attempts to improve this relationship. This calls for a re-orientation of present policy efforts on industry-research interfaces. We have to note that policy should address a wider industrial community, than the MNEs alone. Different target groups from the business sector will need different interfaces.

In deciding where to make R&D related investments MNEs are predominantly following the overall company strategy where general conditions for competition and innovation (tax, labour markets, government regulations) and proximity of markets are prevailing over the presence of specified knowledge. In many cases R&D settlements follow the location of manufacturing sites. Nevertheless given the fact that some MNEs are clearly moving towards decentralisation of the R&D functions within the corporation, there is more room for specialised R&D labs in areas that have proven to provide knowledge excellence and skills in given technologies. **This would support the European policy approach to promote 'centres of excellence' that have a clear international profile as world leading in their area of science.** Having acknowledged centres of excellence would attract and embed R&D investments not only from European MNEs but world wide.

**An important partner in outsourcing R&D, in particular pre-competitive R&D appeared to be the high-technology start-up companies.** In comparison with the more formal public research infrastructures these are highly specialised and commercially oriented organisations that provide knowledge near to the core areas of the MNEs. Having a large pool of these high-tech start-ups in a national system of innovation would make its fabric more attractive for R&D investments by MNEs. The policy implication is that the promotion of leading edge start-ups would add to the attractiveness of a national system of innovation. Germany has

been very active in supporting this business start ups and new regional technology networks are arising from business ventures in areas such as nano-technology, information technology and bio-technology. In the UK this area has been picked up by commercial venture capital initiatives and entrepreneurial universities. The Netherlands and Ireland are late comers to this area and are only just launching initiatives in some technology areas.

**Having a highly qualified workforce relevant for their most strategic functions (R&D, marketing, finance) is the key asset for MNEs.** This means that good universities are an important recruitment pool for skilled staff and particularly research personnel. The education function of universities are often as important as their research capabilities. There was concern in some countries (Netherlands, Ireland) that the quantity of graduates is not sufficient to satisfy skills requirements in those countries particularly in the hard sciences and engineering. In policy terms this means that actions should be launched to address the shortages in these specific areas.

MNEs are active in shaping the curricula of graduate and post-graduate programmes. They have representatives in university governing boards, take part in committees evaluating faculty programmes, sponsor research graduates, offer training facilities and so on. In countries such as the Netherlands and the UK a joint position as university professor and in a MNE R&D research lab is quite common. In Germany this type of mobility was uncommon. Human mobility between MNEs and the public research infrastructures is an important mechanism for building networks and establishing tighter collaboration patterns. National **regulations** such as higher education laws that restrict these interactions between universities and enterprises, will hamper the knowledge flow between important actors in the national innovation system.

The protection of **Intellectual Property Rights** was only a prominent issue for companies active in the life sciences. Here a restrictive ethical and legal framework to develop new technologies influenced investment decisions in favour of areas with fewer restrictions. A closer European co-ordination on these issues would prevent that national governments compete on this issue, at the cost of the quality of life of some Europeans. In Germany the debate on ownership of patents was an issue for debate for MNEs, since ownership is spread over as many individuals as have contributed to a certain research result. This was considered to hamper the negotiations on license agreements between companies and research organisations. Some European guidelines on how to deal fairly with the patent licensing could improve the exploitation of research.

**Although all MNEs agreed that national and European R&D subsidy schemes are interesting to explore new technological paths, and establish new partnerships, the schemes do not have the critical mass to influence R&D location decisions.** In comparison with their internal budgets for R&D the public funding was relatively small. The funded R&D projects are not used to develop strategic research in core company technologies, rather areas that could be of interest for the future. MNEs find that the normal procedures are too slow to really use them to develop leading edge technologies. The policy implication is that there is no point in designing R&D subsidy schemes to the specific needs of the large multinationals, with the objective to embed them in the country. Indirect policy actions aimed at improving the overall conditions for knowledge creation, skills development and innovation will have a longer term impact.

In relation to the specific national systems of innovation the main conclusions depend on the role of home-based versus the host-based multinationals.

**Germany** showed a relative large share of home-based multinationals with still a centralised R&D (and patenting) strategy. A difficult interaction between industry and research, particularly universities is the key policy issue for the future relationship with its home based multinationals. The cultural gap between the two parts of the system is still immense and mobility relatively low. A key policy priority should be to establish better incentives for the HEI system to work together with industry and to lower the barriers for human mobility. Given the global search for excellence the German policy approach to support regional ‘Kompetenzzentren’ existing of a mix of public and private R&D actors, is very appropriate to embed home based multinationals as well as to attract research investments by host multinationals.

The **UK** with its high share of host-based companies that perform research has benefited from a historically built reputation in science excellence, particular in its Oxford and Cambridge institutions. It is also related to other European headquarter functions which the UK has taken over the past decades, with London as a magnet for general business investment. Its more entrepreneurial culture has given the UK a European lead in

creating high-technology start ups and venture capital for new technologies. Maintaining this excellent position in a wide field of science areas will be the main policy challenges for the coming years, particularly after a period of cut downs in spending on basic science.

The **Netherlands** which has been traditionally dependent on a small number of multinationals has developed close ties with its national champions in terms of R&D policy. The study shows however that direct support for R&D in the form of financial incentives is less important than providing an overall climate that is conducive to innovation. The lack of clear international profiles of science excellence where Dutch science can compete with the world best, in combination with severe skill shortages in key technology areas, could deteriorate the system's interaction with the leading MNEs. The attractiveness of the Netherlands for host multinationals based on R&D expertise alone will be modest. The low- key policy efforts for start-ups, is another issue for concern given their role as R&D partners.

**Ireland** has hardly any Irish-owned multinational firms that have an impact on the national innovation system. The host multinationals which perform a large share of Ireland's business R&D are only recently establishing networks with the remainder of the national innovation system, such as its universities. The research resources of Ireland are too small in absolute terms to really influence R&D location decisions or to provoke major MNE investments in their country. Neither has Ireland come out of the patent statistics as a country of inventors and MNE subsidiaries with considerable own innovative competencies. The Irish government has understood that its main challenge is to increase the quantity and quality of the NSI in order to embed the host companies and remain attractive as investment location. It has decided to boost its government spending in this area radically. The next bottleneck asking for policy action, is finding the people with skills to perform these research tasks.

Summarising, research excellence and a highly skilled workforce are the key assets on the basis of which both home-based and host-multinationals make their R&D investment decisions. For national policy makers this means that to tie home-based MNEs as well as attract foreign MNEs, a permanent upgrading the quality of the national system of innovation and its people.

#### 4.1.6. Challenges on SSIs: towards a phase II?

SSIPs are faced with a central institutional change in the present phase of economic development centred around the forms of competition, influencing the ways in which economic transactions are informed and conducted. Such situation is common to all developed economies which in itself is an important feature of the contemporary transformation (which confirms its international nature).

The comparative statics analysis performed on the SSIP tells us that these systems, which had been identified in Amable et al. [1997], change very slowly, not only in terms of scientific and economic specialisation, but also in terms of institutional specificity. One should not expect too rapid changes in terms of industrial specialisation at the industry level considered in the course of this project. Competitiveness is a slow-building process and changes in relative positions take decades rather than years. Some intra-industry changes are nevertheless observable, which may not be minor from a macroeconomic point of view if one takes into account that the 'new economy' is based on the dynamism of a few key activities, mostly around ICT, but these changes do not radically alter the general pattern of specialisation of the countries under study.

It would however be misleading to conclude that nothing changes in SSIPs. The analysis of economic performance in connection to institutional specificity must avoid two mistakes: the first one is to consider that all countries are subject to world-wide trends that leave no room for variety among developed economies, and to apply a 'one size fits all' analysis to modern capitalist economies. There are various instances of this mistake, the most common takes the form of a recommendation to adopt the institutional features characteristic of the country which enjoys the best macroeconomic performance at the time of the recommendation (France in the 1960s, Germany in the 1970s, Japan in the late 1980s, the US in the late 1990s,...). Another variant is to isolate a key mechanism of evolution of modern capitalist economies affecting all countries, for instance financial liberalisation. The next step is to conclude from the forms that this evolution takes in one country (usually the country which has the best macroeconomic performance at the time) that all modern economies will (or should, depending on how normative one wants to be) take the same path, regardless of the structure of the national economies concerned. This is in a way an evolutionary argument. There is a new general evolution principle for developed economies to which countries should adapt or die.

The second mistake is to consider that variety is so significant that the evolutions that affect all economies at the same time are of secondary importance compared to the structural inertia that characterises the various types of capitalism. Technological revolutions may come and go, the hierarchy of institutional forms may be altered, internationalisation may take different forms, Germany will always be Germany, etc.

In order to overcome this dilemma, one must explicitly take into account two dimensions for change. The first dimension is the global one, that of trends and evolutions which concern the world economy and all countries at the same time. One includes in these global trends all the changes we have gathered under the term of 'internationalisation' and which refer to the new patterns of technology transfers, exchange of services, the evolutions of the financial systems... These changes manifest themselves by a change in the hierarchy of driving institutional forms.<sup>11</sup> The forms of competition exert a prominent influence on the way the complementarity of institutions in each SSIP or country is organised so as to define a coherent and viable system. To recall, the dominant form of golden-age capitalism was the wage-labour nexus.

The second dimension is that of the internal logic of each SSIP, a logic we have analysed as institutional complementarity. How does this complementarity evolve under the influence of its own components. In other words, does the dynamics of the different institutions whose complementarity constitute the systems lead to a destabilisation of the system itself. The fact that a static complementarity exists at one given moment does not imply that all institutions are going to stay put until the end of time.

One simple way of taking explicitly into account both dimensions of change would be to consider evolutions affecting the SSIP as the result of both types of evolution: changes which are specific to each SSIP, as consequences of each SSIP's own dynamics, and changes which concern all SSIP. One would for instance consider that SSIP do change radically overnight, but slowly evolve, with incremental changes at the margin, under the influence of factors pertaining to the two dimensions referred to above. This would explain why diversity among capitalist economies might be preserved in spite of global changes which seem to affect all economies in the same way at the same time. This position is not without empirical support, as proved by the analyses presented above.

Another way to look at the problem would be to differentiate among the factors of evolution belonging to either dimension, i.e. the SSIP-specific and the global changes, and isolate changes which could be considered as radical from those which are more incremental in nature. Intuitively, one suspects that if some changes have far-ranging consequences in either dimension, the idea that systems evolve incrementally at the margin may be wrong. But the theory of institutional complementarity tells us more than that. In order to have far-ranging consequences, changes do not have to be 'radical'. Even a seemingly minor change can threaten the pattern of complementarity and induce a change in nature for the whole system.

The hypotheses we took were that changes in forms of competition could produce some seemingly minor changes in the concerned areas, which could threaten the stability of some SSIP. Among the transformations of the forms of competition, one can consider more specifically all aspects of internationalisation and changes in financial systems.

The general change in the forms of competition has pressed for a more rapid flow of innovations and therefore for a more dynamic, risk taking behaviour regarding the financing of innovations. This common drive for a "venture capital" was given very different answers according to the type of financial system and to the other characteristics of the SSIP. Analysing the diversity and the rapidity of these answers gives a good illustration of the dynamics of institutional change. Our analysis stressed the dominant positions of some early which reacted promptly to the need, it shows how some traditional banking has been able to adapt its structures or how some public based system also showed adaptive capability.

A parallel characterisation of the SSIP could have been tracked down following how countries adapted to the globalisation of some part of scientific knowledge (see Archibuggi and Michie, 1997) produced by a new relationship between science and economic activities (see Gibbons 1995, Veltz, 2000) and by a development of the personal and electronic relations between international communities of scientists. The adaptation to such global changes in technology transfers could have taken various routes, from reorienting the educational systems (which takes time) to importing qualified manpower and know how, either by means of brain drain

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<sup>11</sup> See Amable [2000].

(an highly specific mode of adaptation which imply a good attractiveness of the country under view ) or by means of international organisations such as MNEs. The development of large metropolises could also facilitate this dissemination of knowledge. In that respect we took a functionalist perspective (how some kind of specific challenge has been faced in one country or other) but there are complementary perspectives that have been followed in the research project that focus on the means used to achieve these various goals.

The role of MNEs for instance can be seen as evolving during the present phase of internationalisation. Regarding both finance and R&D they seem to be less attached to their home countries. In such second phase MNEs would be important actors in setting some new forms of international organisations. The distinction between host and home countries in that respect would be significantly modified.

Similarly changes in the economic geography of the economies under view tend to stress a new balance between local and central governance of economic activities. This new balance is bound to affect SSIP. The change is the SSIP in the new context will reflect this new balance. This new geography brings also the question of agglomeration effects in large metropolis.

As the evidence presented in the previous sections show, some SSIP have been more robust than others. Considering the evolutions concerned, it is not surprising that the market-based SSIP has maintained its stability, accentuating its characteristics. But the current vogue of market mechanisms should not conceal the fact that among the countries belonging to this SSIP, only the US enjoy a clearly outstanding macroeconomic performance (see for instance Figure II-1 above). In other words, and this is not surprising, there is no univocal link between a certain institutional architecture and certain macroeconomic performance.

The meso-corporatist SSIP has kept most of its specificities, the only change with respect to the previous decade concerning the macroeconomic evolution. The SSIP which is characteristic of South-East Asia has experienced its worst decade since the end of the second world war. Countries specialised in mass-production ranging from average (Korea) to very high (Japan) quality have found it difficult to adapt not so much to a new type of product innovation (less incremental) than to the new phase of financial liberalisation. This last factor threatened the whole structure which had supported their tremendous economic success for several decades.

Changes in the pattern of internationalisation has had more influence on the other two SSIP. Finland and Sweden, the more technology-intensive countries of the social-democratic SSIP, seem to follow separate paths from Norway and Denmark. Norway seems to some extent closer to the market-based SSIP whereas Denmark has some common characteristics with the public SSIP.

This last SSIP appears once again the less homogeneous and the less stable of all systems. Both internationalisation and financial liberalisation have subjected the countries of this system to divergent evolutions. Italy shares important common characteristics with the Mediterranean countries, as far as foreign trade, technology and specialisation are concerned. On the other hand, Germany and the Netherlands are closer to some countries of the Social-democratic SSIP than France or Belgium. These similarities or dissimilarities already existed at the time of the analysis performed in Amable et al. [1997], but it appears that no convergence has been underway since.

The evolutions concerning the financial system and corporate governance have also questioned the homogeneity of this SSIP. The dominant evolution was a weakening of the traditional bank-based systems and a growing importance of disintermediated finance in every country. But this general trend has not had the same consequences in every country. The most solid bank-based systems (Germany, ...) have been more resistant to change than the less solid ones (France, Italy, Belgium), where the rise of market finance and the decline of not very profitable banks have quite logically co-evolved. This has had consequences for corporate governance and, one suspects, the type of investment that firms will undertake.

Questions concerning Europe are then centred on the heterogeneity of countries in the EU. This heterogeneity is not a problem *per se*, but with respect to a common European technology and industrial policy. Considering the various SSIP European countries belong to, it is obvious that European policies regarding competition, deregulation, privatisation, etc. are going to have different consequences on the dynamics of countries according to whether they are part of the market-based SSIP, the social-democratic SSIP or the public SSIP. As the analysis already shows, the latter system appears the more fragile of all, all the more that

the countries belonging to this system have mostly had mediocre economic performance during the 1990s. One may argue that subject to policies that seem to steer countries toward an extension of market-based mechanisms, the fragility of the public SSIP will imply a radical change for countries belonging to this group. Consequences for innovation and technology may be far-ranging since the specific form of innovation favoured by this SSIP (programs, rather radical technological advances,...) may be endangered.

Another aspect concerns the regional dimension of technology. The results presented above do not indicate a radical autonomy of the regions from their home countries in their economic and technological development. The 'technological geography' of regions is of course more complex than that of countries, but what comes out the analysis does not contradict the prevalence of 'macro', national-level institutions over more local dynamics. This does not mean that regions have no development autonomy, but that this development takes place under the influence of the macro-level institutions that define the SSIP. Therefore, the effectiveness of regional policy will crucially depend on the institutional features of the countries the regions belong to.

## 4.2. Policy Implications

### 4.2.1. The framework of analysis

A. We hereafter present some of the main policy implications drawn from the various work packages of the CDIS project.

The interest of this synthesis is to put together policy issues on the internationalisation of innovation systems which have been drawn from various perspectives. Some work packages have been looking at the behaviour of firms and their policy recommendations mainly concern how to change their context of operations to boost their competitiveness or their positive effects on the industrial fabric. Other work packages took a meso economic perspective and analysed at national levels the main characteristics of innovation systems, leading to policy recommendations related to the modification of the whole context. We insist hereafter on the interactions at national and international levels and on the problems of co-ordination that these different perspectives may raise.

#### B. The objectives

The first question is to define the objectives to be reached.

The ultimate objective is certainly to adjust innovation systems in order to enhance the competitiveness of countries or group of countries in a regional union as in the case of EU countries. But beyond this general objective what are the concrete and practical objectives to be selected ?

Innovation has two components, namely the creation and diffusion of new products, so that, to innovate, a country must address the question of knowledge acquisition or creation and the one of financing the projects this knowledge suggests.

We can then express the objectives in terms of developing the knowledge base and easing the financing of innovative projects. In a developed market economy such objectives can lead to policies which either concern human resources (and the organisation of labour markets) or the market infrastructures (and the organisation of market competition that regulations and network services provision).

Further more these objectives may differ according to their time horizon (whether it takes a long or short term perspective).

#### C. On the European diversity

We rejected the idea that the policy objective of European countries could be to follow a country model. Our study has confirmed the variety of cases within Europe, even if there are common traits if compared with non European cases. We also showed that if countries within Europe shared some characteristics, they nevertheless differed significantly, which led to various typologies in sub-systems such as science and education, labour market or organisation of product and financial markets. These structural differences are durable ones and European diversity is a fact, either a positive factor per se for the innovative capability of Europe or a factor which policies have to turn into a positive one.

This rules out the idea that the choice of a country model could help to select the policy objective. Given the specificity of countries, policies are bound to be diverse and to take advantage of the partial similarities which we have identified.

#### D. Various kinds of policies

The above suggests that policy recommendation is a complex task, since policies will depend in many ways from the set of countries under view and the type of objectives considered. It may thus be useful to distinguish between various types of policies.

Policies have in common to support successful adjustments of SSIPs. From there, policies can be placed in two main categories:

- the “direct” innovation policies which intend to act on the working of the innovation systems themselves by targeting some specific aspects such as R&D orientation, educational attainments, labour market “flexibility”, or the opening of international relations or finance. Measures in this category are looked at separately. One can distinguish in this category active and passive innovation policies (somehow as it is done regarding labour market policies) depending on whether policies aim to improve the innovation resources for the future or whether they intend to favour either some catching up or scrapping of units of production lagging behind.
- the comprehensive policy actions which try to change the broad context determining the SSIP, taking into account the interdependencies between the above-mentioned aspects, such as the labour market, the finance systems and the international relations as well as R&D and education. This approach focuses on the linkages that may exist between these various aspects, in order to strengthen the policy effects and reduce counter effects.

Both types of policies are complementary. The many recommendations one can design in a direct innovation policy perspective should then be cross-checked looking at the linkages that define the comprehensive SSIP. Taking advantage of institutional complementarities not only broadens the scope of action but also can limit the counter effects that may hinder actions suggested by direct innovations policies. Direct innovation policies conversely help to specify the micro economic rationale for policy actions.

Since the above combination of direct and comprehensive policy actions takes a national perspective, then, the question of the interdependencies between the nations must be raised. This interdependency argument is of course all the more important when countries are in a Union empowered with a specific room of manoeuvre for policy intervention. This argument raises the issue of international co-operation, both at European levels but also at a global level, as it has been clear that most of the challenges of internationalisation (and in particular the organisational choices of Multinational firms). This challenge concerns at least the US and Japan along with the European countries as well as the policy actions of many international bodies starting with WTO. Issues at this level are specific. Again to consider systematically how measures may imply some contradictions at a regional or international level helps check and validate the realism of the recommendations.

For this reason we shall add to the two previous categories of policy a third level of policy interventions, related to the international level, which we shall call strategic innovation policies. The types of issues and interventions concerned by this level will help to assess the kinds of measures required to develop a European research Area. These questions will be addressed at the end of this section.

To speak in more concrete terms, the policy issues will first be presented by fields within two ranges of issues, concerning respectively the development and transfer of knowledge, and that of finance.

Secondly, within each range we shall consider issues which are related to the transformation of key-components of the SSIP, namely the wage-labour nexus and the organisation of markets. This will help to address issues related to the coherence and relevance of the direct innovation policies.

Thirdly, since the two above-mentioned aspects are directly affected by the process of internationalisation, we will add a strategic perspective which takes into account some of the international aspects.

Table 4.1 tries to summarise this frame of analysis.

**Table 4.1: Policy issues and their contexts**

Areas of policy Range of issues	Forms of competition	Wage labour nexus	System level
Development and transfer of knowledge	R&D policies Spatial planning Agglomeration effects Economic geography	Education Wage structure Mobility Leisure policies Consumer policies	Comprehensive approach on knowledge related issues
Development and transfer of finance	Agglomeration effects Development of venture capital and specialised financing	Pension funds Saving Wage structure Mobility	Comprehensive approach on finance related issues
International level	Strategic approach In terms of Competition forms	Strategic approach In terms of wage labour nexus	

#### 4.2.2. On knowledge transfer and development.

##### A. Direct innovation policies

A straightforward way to support SSIP is to *stimulate the R&D content of national activities* as well as the informal exchanges and transfer of knowledge. The present phase of internationalisation with the development of telecommunications, media and international scientific relations has enlarged the range and intensity of such transfers. Organisational changes within and between firms also contributed to this enlargement. This includes the changes in the international organisation of multinational firms (to which an essential part of this project has been devoted), along with significant development in international agreements and joint ventures between large firms and noticeable changes in number and scope of mergers and acquisitions.

The result of this broad structural increase in international transfers is that policies will then (or should) have higher requirements regarding actions they are willing to support. At national level, countries aiming at gaining from hosting an R&D activity from a MNE will target technology transfer that would not occur otherwise. Local policies which benefit in more selective ways of the general increase in knowledge transfer may have more specific policies (largely mixed with local employment concerns). MNEs, on their side, are still strongly attached to their home culture and are not very willing to deploy internationally crucial parts of their research forces, so that factors of attraction have also to be more powerful and specific than in the past. Factors of attractiveness have to be highly correlated with the strategies along which these MNEs want to reorganise.

Two issues are here highly relevant. One has to do with the development of a new relationship between scientific developments - which tend to become more concerned by applications - and industrial activities - which tend to incorporate in their products and processes more and more directly some of the latest scientific developments.

The second issue has to do with the development of infrastructures of large network services in transport, distribution, banking and communication. It should also include business services which set up rapidly important international networks. All these facilities increase the attractiveness of countries and regions for the installation of all kind of activities of multinationals. It should be noticed that all localisation moves are linked and that R&D installation may well follow from the installation of other activities. The bargaining power of any policy trying to promote the development of R&D activities in a host country will thus have to be based on the existence of some good interfaces between research and industry as well as on the reliability of large service networks (benefiting from the whole set of modern capabilities). The existence of large scientific centres fills well the first condition, the widespread reorganisation (and deregulation) of services, meets the other.

Still if such are the attraction factors, the policies cannot change the situation overnight: it is a long term process, where countries will both take advantage of internal synergies and enter into joint venture and co-operation with other countries. The relative inertia leading to slow adjustments is a factor in favour of strategic policies: they suggest that collaboration between diverse countries could help to overcome efficiently some of the shortcomings of innovation systems.

Policy to support the installation of R&D activities whatever the means and the specialisations (division of work between co-operative countries), is obviously an active innovation policy. It effectively aims to develop new sources of innovation.

Conversely actions to facilitate the updating or the scrapping of outdated practices in firms could be qualified somehow of passive innovation policies. As a matter of fact such “creative destruction” on the industrial fabric of SMEs (small and medium size enterprises) could play a major role in the upgrading of SSIP. At a time when the non price factors are playing an increasing role in determining the competitiveness of countries it is effectively crucial to help with the diffusion of modern production methods and access to markets. This modernisation includes the conception of new products and work processes which put the relevant firms on increasingly competitive trajectories

All these direct innovation policies (whether active or passive in nature) are more specifying targets than instruments. Moreover such a solution does not concern SMEs which are more dependant upon local infrastructures than on the existence of large agglomeration and infrastructures.

We still have to consider another direct policy, namely the development of education. Clearly innovation systems tend to call for more education at all levels. This rise in educational concerns is effectively a long term trend in all the developed economies under view, quite unaffected by the depressed labour markets of the 80s and early 90s. Still what kind of policy recommendations can we advocate? The above strategy calls in itself for the training of the high skilled workers of the large science centres under view. To ensure the production of the required professional skills is a necessity. But the fact is that the exact requirements of such high skilled professionals remain uncertain and depending of the type of countries and the exact nature of the activities under view. In some country the substitution of lower skills to professionals will be feasible, in some others, it will be unlikely.

In contradiction with this active innovation policy of increasing the number of skilled workers, one could refer to passive innovative policy, which are in charge of coping with the obsolescence affecting past formal training. Again these objectives are more decentralised and their attainment cannot simply be provisioned by the supply of local labour market of professionals. The forms of actions are bound to be more diverse and based on some broad networking....

Other direct measures beside education, like international mobility of professionals or life long learning or improving regimes of intellectual property rights, could be similarly envisaged, but it seems more on line with our approach to list at this stage some of the comprehensive issues which can help to schedule the various policy instruments that will help reach the targets.

#### B. Taking a Comprehensive Perspective

A comprehensive perspective within the broad range of policy issues mentioned above basically stresses the specificities of countries and the kind of policy instruments that are more likely to be efficient. Countries under view belong to different clusters regarding both the forms of competition and the types of wage labour nexus. The major distinctive characteristics refer to the relative role of public and private sub-systems, the place given to market mechanisms, the type of social cohesion that is looked for, as well as the centralised or decentralised nature of the governance mechanisms. In itself, such a typology clearly suggests tax and price incentives in countries favouring market mechanisms, on one side, and public institutions efficiency and public bid in countries more inclined to direct public interventions This may effectively contribute to re-enforce the effects of active innovation policies. In the case of passive innovation policies, which denote relative failures, it may well be the case that unusual mechanisms should be preferred (public direct interventions in countries prone to use market mechanisms and conversely tax and price adjustments in countries used to public interventions).

What could be the impact of the internationalisation process on these policy recommendations ?

The broadening of the internationalisation process provides new means to transfer knowledge. Some schemes to diffuse information and knowledge could become obsolete and force some upgrading or scrapping, a destruction which is not always easy to implement. Secondly, the pressure of external competition as well as

the liberalisation of markets, may reduced the scope for tax and price adjustments. Both mechanisms are thus transformed and their border lines moved.

Accounting for such erosion, it is suggested to follow active policies adapting the instruments to the new international context. There is the feeling that while internationalisation is forcing a rapid transformation of 'exposed' institutional sub systems such as trade and finance, the changes are much slower and pressures lower in the 'sheltered' sectors, such as labour market, social protection, scientific specialisation, etc....

These sheltered sectors tend therefore to condition strongly the forms of policy that can be implemented in the exposed sectors, as exemplified in the case of the changes occurring in the financial systems.

#### 4.2.3. On finance transfer and development.

##### A. Direct innovation policies

The role of finance in innovation has been largely stressed following Schumpeter's insistence on the fact that finance was the first reality test for any innovative project. The long term growth of our economies have thus largely been backed by the development of financial systems that could support the entrepreneurs' initiatives.

Financial systems help in the end to transfer finance from old to newly created activities.

In the first place internationalisation - which is primarily internationalisation of finance - should make this financing easier. Indeed such was the effect some decades ago when the deregulation of banking systems started and when the old international monetary regime created at Bretton Woods collapsed. But with the diffusion of a new technological system and the evolution of the norms of competition the effect of internationalisation on the financing of innovative project has been apparently less straightforward.

It has become important for each country to adjust its own capacity to finance risky projects to what its competitors did. Therefore developing the ways the economy can select and support risky projects has become a major challenge.

We have looked extensively in this research on this transformation and found that most countries developed rapidly some new forms of financing risky projects in the late 90s. These forms, though highly country specific, are still far from having reached the level they have in the US. Further more there are still sizeable differences among countries in the levels of development of these new forms of the financing of innovative projects. But even if the level of venture capital raised is rapidly growing, it remains that European countries still lag well behind the result achieved in the US (where it also represent a modest share of total investment).

In that sense supporting schemes for this sort of financing can take many forms, in accordance with the characteristics of the prevailing type of financial system. The analysis done in the project showed that countries either relied on "purely" financial market mechanisms or on banking and public institutions to develop venture capital forms. Direct innovation policies can accordingly support the relevant national scheme.

There is in these developments a strong sectoral dimension. To appreciate how risky are innovation projects under view, specific tacit knowledge of the sectors concerned are necessary. A lot of venture financing has thus concerned activities linked with the information and communication technologies and to a lesser degree biotechnology. The financing of ICT activities has acquired a global reach under the leadership of American experts and capital venture firms.

Policy actions could contribute to the availability of expertise needed to develop such venture capital in specific sectors, beyond ICT activities. This would be all the more welcome that the gains expected from the transformation of productive processes are essentially tied with successful uses of ICTs in key service sectors (of health and education for instance) more than in their direct production.

Conversely one should not pretend that successful uses of ICT products and services could be done independently of a close knowledge of the inner dynamics of development of ICT products and services. Therefore active innovation policies of the above type should be backed by kind of "passive" innovation policies helping local firms to catch up with the dynamics of the ICT industry. Of course this is all the more easy that countries have a niche in these industries that can be maintained or developed. But this leads to a strategic perspective where the role of Europe as such may help to have a more active innovation policies in the field of ICT products.

All the above policy schemes, active or passive, should finally favour the development of start up firms. All the contributions to the CDIS project did stress that in the contemporary phase of development, the innovation frontier was largely developed on an external basis, small start up firms launching new risky projects and large firms buying out at some stages the successful experiences. So far this form of externalisation has been found to be an efficient way to combine risky projects with a tight constraint on competitiveness norms and profitability norms imposed to large firms.

#### B. Taking a Comprehensive perspective

A comprehensive approach would insist on the fact that policy schemes must and can be adapted to the types of financial systems of the countries under view.

Our studies have shown two main types of adjustments: market based or “public and bank “ based mechanisms. Looking at the general context of such financing process is also important, because, if venture capital risk is only financing a tiny part of investment, it is nevertheless influencing the behaviour and strategy of the whole system. Hence the importance of new procedures of certification and control, the development of legal rules which facilitate the spread of new behaviour in the whole financial systems. But countries are definitively different regarding the use of such procedures. Some are more ‘legalistic’ than others. Tacit rules, conventions, tutelage from public bodies or large firms play their roles in the matter. Policies should certainly take into account these different practices and be designed accordingly, even though the specificity of countries has been reduced and a general drive towards new institutions observed. A good example is given by the diffusion of secondary stock markets for innovative firms which clearly facilitated the exit phase of venture capital and therefore its development (as well as it facilitated the entry of standard financing bodies into supporting innovative firms).

Changes in the forms of competition, which is a major common trait of the actual growth regime of developed economies, explain the universality of such institutional change. This common dynamics of institutional change, even if it is widely shared, is not enough in the present phase of internationalisation to ensure a similar development of countries. A lot of issues cannot be solved at country level: such is the case for instance of Intellectual Property Rights (IPR), a major element in the overall contemporary dynamics of innovation where as we saw the knowledge basis of some leading activities becoming instantaneously global. This refers to the core international strategic dimension that innovation policies must develop in the present phase.

#### 4.2.4. On strategic policies looking at international co-operation and competition.

Our studies in the CDIS project often stressed the lack of international co-operation in issues such as the localisation of MNEs, the opening of financial markets and venture networks, the management of intellectual property rights, the development of top quality science centres or of basic research schemes.

A key issue in that respect is whether regional agreements and developments can fill this need. This raises the question of the European Union and what can be developed at its level.

The answer is somewhat balanced. Obviously, many issues can be solved at this regional level (when they cannot be addressed for some of them at national level, see the IPR issue). Still this regional level is also deeply interlocked with a global level where actors, mainly MNEs, have been developing their strategy.

Still the role of Europe can be usefully developed in many directions to facilitate the adjustment of member countries as well as to give the whole Union a substantive role in the shaping of arrangements at the global level.

The role of EU integration in the dynamics of the EU SSIP types is definitively helpful – sometimes crucial - for member states to catch up with world-wide common trends (knowledge society) and to take advantage of some EU-specific aspects (as given by wage labour nexus paying on average more attention to social cohesion issues or deeper commitments of the citizens to preserve and improve the quality of life in European societies).

The question though is whether such policy lines should be developed at the level of Europe as a whole or at the levels of sub groups of European countries which are closer in how they address the welfare issues.

The development of an Euro group, even if it gathers a majority of member states, has definitively paved the way for such path of “à la carte” developments.

Regarding innovation policies such developments have limited scope, as many issues are also addressing global issues and since, in such cases, a divided Europe is weakening the common position. The studies of this CDIS project, because they are much concerned with international, world wide, issues, would suggest that Europe definitely needs common stands on all the major (common) changes regarding the forms of competition. Conversely for what concerns the sub systems which are more sheltered, it may well be the case that European actions could develop in a step wise manner, developing common stands within rather homogeneous groups. This concerns in effect the labour market but also all these large systems such as education and health, which are bound to play an important role in the shaping of the new growth regime. Allowing some room for manoeuvre in these fields could be fruitful and support a general developmental trend. This way to deal with European diversity does not overlook the common need to support deep transformations in key domains. The recognition of such community of objectives, though differentiated in some cases as we just stressed, could help to guide the building up of a European research area.

Such European research area should be in coherence with world wide trends in terms of the advent of a knowledge society, which means an increase in the volume of a number of activities (S&T, RD, higher education ...)

Secondly, this European research area should take into account and build on the features of the EU-Area SSIP model: such features are shared by EU member states, but in forms which are specific to them. They constitute both constraints and opportunities which are at the root of EU specific comparative advantages in world competition. The socially protective labour regulations can represent advantages in terms of attractiveness and know-how accumulation both in the public and private research and innovation sectors ; income equality is the basis for large demand of high quality goods and services, as well as a potential for skilled labour. We suggest the present challenge is largely to characterise better what could be considered as a European social system of innovation and production and its implications for the European research area in terms of building comparative advantages out of those specificities (at world level), which we share (at EU level).

Yet the risks of divergence that the diversity of European SSIPs contain should not be underestimated and appropriate resources developed to avoid the development of centrifugal forces. The Union in that respect may favour the development of community based institutional schemes in most cases where innovation policies are aiming at some catching up or scratching (what we called the passive innovation policies) in order to avoid a broadening of the gap between countries more inclined to rely on market mechanisms and countries more inclined to rely on national schemes to promote the innovative capability of their economy. In that respect policies aimed directly at the quality of life and welfare of European citizens would be clearly both the best political support and the more effective grounding of economic growth at a time when the decisive step for a durable growth concerns the reconstruction of an “updated and upgraded” effective demand.

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## 5. Dissemination and / or exploitation of results

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### 5.1. CEPREMAP (Paris)

Bruno Amable, *Institutional Complementarity and Diversity of Social Systems of Innovation and Production*, WZB working, ISSN Nr 1011-9523, September 1999, paper accepted for publication in *Review of International Political Economy*, 2001.

Bruno Amable, Régis Breton, Xavier Ragot, *Innovation, finance and the boundaries of the large corporation*, CEPREMAP Working Paper, November 1999.

Bruno Amable, Yann Cadiou and Pascal Petit, *On the Development Paths of Innovation Systems*, Work Package D, November 2000 (first draft presented at the fourth CDIS Workshop, Paris, 12-13 October 2000).

Bruno Amable and Sandrine Paillard, *Intégration européenne et systèmes financiers: y a-t-il convergence vers le modèle anglo-saxon ?*, contribution ouvrage collectif A.Torre éditeur, 2001.

Bruno Amable, Sandrine Paillard, Pascal Petit, *Finance and Innovation: Venturing on the Risk Frontier*, working paper presented at Journées CREI-Recherche et Regulation, University of Paris XIII Villetaneuse, 3-4<sup>th</sup> December 1999, submitted for publication.

Bruno Amable, Pascal Petit, *Identifying the Structure of Institutions to Promote Innovation and Growth*, CEPREMAP Working Paper n° 9919, 1999, Work Package A, first version presented at the 2nd CDIS workshop, Paris, 19-20 march 1999 and at the annual DRUID conference in Aalborg, June 1999, submitted for publication.

Pascal Petit, *Technology and Growth: Between Regionalisation and Globalisation*, to appear in Baddeley M., Mc Combie J., Aretis P., *What Global Economic Crisis?*, Mac Millan, 2000.

### 5.2. OST (Paris)

1. OST has provided some of the data prepared for its workpackage to its partners for their own research needs.

2. the regional part of the research has provided elements which will be used for:

- the preparation of the French response to the 'mapping of excellence' exercise of the EU Commission,
- the next version of the OST indicators report,

3. the national innovation systems comparisons part of this research:

- has contributed to a PhD dissertation on 'comparative analysis of the Japanese and French innovation systems'
- has given, the opportunity to set up a data base which will be used by various researchers in France,
- will be used as a background document for various seminars, in particular the Europolis Conference organised by OST in linkage with the commission,
- will be presented on the OST site and should be the basis for publications,
- will be the background document for a further investigation of the comparison with Japan, in relationship with the scientific attaché in the French embassy in Tokyo.

### 5.3. Rotterdam School of Management (Rotterdam)

1. Seminar: November 2<sup>nd</sup> 2000, a seminar was held on internationalisation and R&D in which prof. Nooteboom en prof. Dunning participated. Location: Erasmus University. The seminar received a major input from the research group.

2. Eight different papers have been made for each of the relevant topics of the research:
  - On National Systems of Innovation: by Brechje Albert, Rob van Tulder and Andreas Wulff
  - On international innovation strategies: a literature overview; by Brechje Albert
  - On the interactive nature of innovation: by Paul Beije
  - On international R&D arenas; by Rob van Tulder
  - On the interaction between NSIs and MNEs; by Patries Boekholt and Maureen Lankhuizen
  - On nine cases of multinational organisations in R&D; an interview paper by Maureen Lankhuizen
  - On the relationship between R&D and core companies; by Douglas van den Berghe and Rob van Tulder
  - On internationalisation of Patenting; by Francoise Laville (OST), Rob van Tulder and Maureen Lankhuizen
3. The manuscript on interactive innovation will be send to a publishing house for publication.
4. Research briefing in Phoenix (AIB) and in Maastricht on the SCOPE databank, will be partly based on the results of this research project (linking internationalisation data with R&D and patenting data).

Two papers are in preparation for publication in a scientific journal: one on R&D systems and policy consequences; one on international R&D strategies of firms.

#### 5.4. TIK (Oslo)

##### **Teaching**

Fagerberg, Jan: Data and perspectives from project used within teaching of MA-course "Society, Science and Technology in Europe", University of Oslo, Autumn 1998-2000 and Spring 1999-2000.

Grønning, Terje: Data and perspectives from project used within teaching of MA-course "Society, Science and Technology in Europe", University of Oslo, Autumn 1998-2000 and Spring 1999-2000, and within guest lectures at Gothenburg University (Sweden, May 2000), at Linkoping University (Sweden, April 2000), and at National University of Science and Technology (Trondheim, Norway, May 2000).

Grønning, Terje and Rajneesh Narula: Perspectives from project used in connection with tutoring thesis for the MA-degree in Society, Science and Technology in Europe *Research and Development by UK Chemical Multinational Enterprises* (Drosten, Thijs, University of Oslo and Maastricht University, 1999).

##### **Conference papers**

Fagerberg, Jan (1999). "Technological Progress, Structural Change and Productivity Growth: A Comparative Study ", paper presented at *Economic Dynamics and Structural Change Workshop*, Eindhoven, October 3-4, 1999.

Grønning, Terje (1998). "The concept of institutions within systems of innovation-approaches", paper to *Thorstein Veblen Conference on Institutional Analysis of the Economy Today: Conceptual Cores, Analytical Applications and Challenges to Institutional Analysis*. Oslo, 18-19 June, 1998.

Grønning, Terje (1998). "The Chicken and the Egg", editorial for the e-mail network *Economic Sociology* (ECONSOC@listproc.hcf.jhu.edu), 1 September, 1998.

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Grønning, Terje (2000). "Transnational Coordination of R&D: The European R&D activities of the Japanese Printing Inks Industry", Paper to the *XVIth European Group for Organization Studies (EGOS) Colloquium*, 2-4 July 2000, Helsinki, Finland.

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Grønning, Terje (1998). "Whither the Japanese Employment System? The Position of the Japan Employers' Federation," *Industrial Relations Journal*, Vol. 29, No. 4 (December, 1998).

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6.1. CEPREMAP (Paris)

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### 6.3. Rotterdam School of Management (Rotterdam)

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#### 6.4. TIK (Oslo)

##### **Acknowledgements**

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## 7. Annexes

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### 7.1. List and status of the deliverables

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#### 7.1.1. CEPREMAP (Paris)

##### **Work Package A**

Bruno Amable, Pascal Petit, *Identifying the Structure of Institutions to Promote Innovation and Growth*, CEPREMAP Working Paper n° 9919, 1999, Work Package A, first version presented at the 2nd CDIS workshop, Paris, 19-20 march 1999 and at the annual DRUID conference in Aalborg, June 1999, submitted for publication.

##### **Work Package D**

Bruno Amable, Yann Cadiou and Pascal Petit, *On the development paths of innovation systems*, Work Package D, November 2000 (first draft presented at the fourth CDIS Workshop, Paris, 12-13 October 2000).

#### 7.1.2. OST (Paris)

##### **Work Package B**

An up-dating of a previous data analyses on the institutional determinants of innovation patterns and their consequences for economic performance: **Done (see OST WPB research report)**.

A comparative analysis of selected European innovation systems Done (see OST WPB research report)

A detailed study of recent changes in the Japanese system of innovation, including technology policy (government) and R&D strategies of large Japanese firms, and an assessment of the consequences for Europe → **ESST – TIK ?**

A synthesis report on: “ The contemporary systems of innovation: statistical and institutional evidences and external challenges” **Done (see OST WPB research report)**

Rémi Barré, Sandrine Paillard, Yann Cadiou, Sandra Petit, The contemporary systems of innovation: statistical and institutional evidences and external challenges, Work Package B, Report presented at the fourth CDIS Workshop, Paris, 12-13 October 2000.)

##### **Work Package C**

Michel Zitt and Suzy Ramanana-Rahary (in collaboration with Françoise Laville), S&T Co-activity in regions: an insight in geography of knowledge-based activities in EU, paper presented at the fourth CDIS Workshop, Paris, 12-13 October 2000.

#### 7.1.3. Rotterdam School of Management - University of Rotterdam (Netherlands)

##### **Work package C**

Robert van Tülder (co-ordinator), Interactive Innovation, Multinationals and Systems of Innovation: towards an international interactive perspective, Work Package C, Report presented at the fourth CDIS Workshop, Paris, 12-13 October 2000.

#### 7.1.4. TIK (Oslo)

##### **Work package A**

(a) Grønning, Terje (1998). “The concept of institutions within systems of innovation-approaches”, paper to *Thorstein Veblen Conference on Institutional Analysis of the Economy Today: Conceptual Cores, Analytical Applications and Challenges to Institutional Analysis*. Oslo, 18-19 June, 1998 (available at <http://www.uio.no/~terjegro/papers/veblen.pdf>).

(b) Grønning, Terje (1998) (ed.) *Rethinking the institutions governing innovation in the new era of internationalization*, proceedings from conference held in Oslo, Norway, June 21st-23th, 1998, organized by Comparative Dynamics of Innovation Systems (workpackage A) project funded by the Targeted Socio-Economic Research (TSER) program of the European Commission (DG XII) under the Fourth Framework Program, European Commission.

**Work package B**

(a) Fagerberg, Jan (2000). "Technological Progress, Structural Change and Productivity Growth: A Comparative Study", forthcoming in *Structural Change and Economic Dynamics* (SCED).

(b) Grønning, Terje (1998). "Whither the Japanese Employment System? The Position of the Japan Employers' Federation", *Industrial Relations Journal*, Vol. 29, No. 4 (December, 1998).

(c) The scheduled sub-study "Japanese Innovation Policy: The Nature and Context of the Japanese Innovation Study Group's interim report" (Grønning) was due to methodological circumstances dis-continued and resources moved to the sub-project "Multinational R&D, Corporate Organisation and Innovations Systems" (see Workpackage C).

**Work package C**

(a) Grønning, Terje (2000). *Multinational R&D, Corporate Organisation and Innovations Systems: A Study of the Domestic and European R&D-activities of the Japanese Speciality Chemicals Industry*. Report to the European Commission's Targeted Socio-economic Research (TSER) programme under the IVth Framework programme.

**Conference held in Oslo, Norway, June 21st-23th, 1998: Rethinking the institutions governing innovation in the new era of internationalisation**

Proceedings from conference held in Oslo, Norway, June 21st-23th, 1998, organised by Comparative Dynamics of Innovation Systems project (Work Package A) funded by the Targeted Socio-Economic Research (TSER) program of the European Commission (DG XII) under the Fourth Framework Program, European Commission.

Seminar programme

**Saturday 20 June - evening**

- organizational matters, final adjustments of planning, informal get-together

**Sunday 21 June**

chair: J. Fagerberg

**9h00 - 9h30**

- objectives of the conference - Rémi Barré

**9h30 - 11h00**

- social systems of innovation (SSI) - B. Amable
- discussants: B.A. Lundvall, K. Smith*

*break*

**11h15 - 12h15**

- current / recently finished research projects - B.A. Lundvall

**Lunch**

chair: R. Van Tulder

**15h00 - 16h30**

- the dynamics of the SSIs in the EU: a quantitative attempt to introduce the regional and MNFs in the dynamics - R. Barré

*discussant: J. Fagerberg*

*break*

**16h45 - 18h15**

- changes within the Japanese system of innovation: a preliminary framework for a qualitative analysis of some basic traits - T. Gronning

*discussants: W. Polt, P. Petit*

**Monday 22 June**

chair: B. Amable

**9h00 - 10h30**

- the case of multinational firms - R. van Tulder

*discussants: R Narula, J. Dunning*

*break*

**10h45 - 11h30**

- current / recently finished research projects: J. Dunning

**11h30 - 12h15**

- current / recently finished research projects: R. Narula

**Lunch**

chair: P. Petit

**15h00 - 15h45**

- current / recently finished research projects: C. Edquist

**15h45 - 16h45**

- current / recently finished research projects: W. Polt, D. Pilat

*break*

**17h00 - 17h45**

- current / recently finished research projects: K. Smith

**17h45 - 18h30**

- current / recently finished research projects: L. Mjaset

evening: preparation of synthesis

**Tuesday 23 June, morning**

chair: K. Smith

**9h00 - 10h30**

- tour de table on key-points and issues

*break*

**10h45 - 12h30**

- synthesis and perspectives regarding the CDIS project

*Lunch*

**13h30 - end of conference**

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**Site of the Conference:**

KLEIVSTUA  
Frydenbygg AS Kleivstua  
Dronningveien  
3531 Krokkleiva

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### *The intellectual background of the seminar.*

The last decade has experienced a significant shift in many research programs in social sciences. First of all, the slow-down in growth rates in industrialised countries, as well as emerging newly industrialised countries has put forward a new concern for growth and development theory. The renewed interest for endogenous technical change is shared both by neo-classical economists and Schumpeterian specialists of innovation. Understanding the complex process of innovation and diffusion of new products and processes is again on top of the agenda for many scholars in social sciences.

But simultaneously, a new issue had to be dealt with: What type of institutions should monitor innovation and technical change and deliver socially desirable results? Are market-based institutional devices best suited to promote innovation and growth or should other institutions be designed in order to reconcile the individual strategies with the attainment of the best social returns ? Many scholars now agree that the very externalities associated with innovations in science and technology, as well as education and training call for significant public interventions on taxes, credit subsidies, patents management and so on.... More empirical oriented international comparisons have shown the strong national diversity in the institutions governing scientific research, technological innovation and diffusion, incentives to product and the process innovation, the ability of personnel to innovate, the propensity of the credit and financial system to finance RD expenditures and science related projects. Many approaches in terms of « national system of innovation », « social system of production », « production worlds », « social system of innovation », « productivity regimes » and « *régulation* modes » seem to converge to some broadly consistent analyses.

One of the major task of the seminar is to organise such a cross fertilisation among scholars who had never opportunity to fully confront their respective analyses and theories. Can a common definition of innovation systems be given ? Is there any convergence in the taxonomy of the various systems already investigated by comparative international analyses ? Can these systems be formalised by tractable models ? This is a first series of questions to be investigated during the seminar.

The seminar will simultaneously address to two other issues, somehow related and which have triggered many new investigations during the last decade. The economics of institutions now deals extensively with the various institutional arrangements which complement the market and therefore economists have to work along with political scientists, sociologists, historians, law specialists. The issue is to understand a complete *architecture of economic institutions*, and it turned out that innovations and their related institutions are a good starting point for building such a theory. But nowadays, if the role of institutions is clearly recognised, fewer researches address the question of *institutional change*, which in fact is crucial in the contemporary world. Why do some countries adapt better and more easily than others ? Is there any strong tendency to institutional sclerosis ? Is rational economic behaviour sufficient to induce a shift to superior institutional arrangements or is a form or another collective action required in order to solve even the simplest co-ordination problems ?

Finally, a third question is quite important in the present context of so-called « globalisation »: how national do the innovation systems and « *régulation* » modes remain ? For some scholars, the very essence of science and technological innovation in high tech sectors is now to operate at a transnational level, since one observes an increasing role of multinationals, transnational partnerships in order to develop new technologies as well as efforts in order to set international rules of the game for patenting, property rights and investment...and even political and social rights. The third set of questions to be addressed by the seminar is challenging and difficult: How to assess precisely the degree of *internationalisation of innovation systems* ? Is the trend uniform or do some societies resist more to « globalisation » ? Should not the concept of globalisation be replaced by more satisfactory ones such as international regime change, “triadisation”... ? What is the precise impact of the new phase of contemporary internationalisation upon the redesign of national or continental economic institutions ?

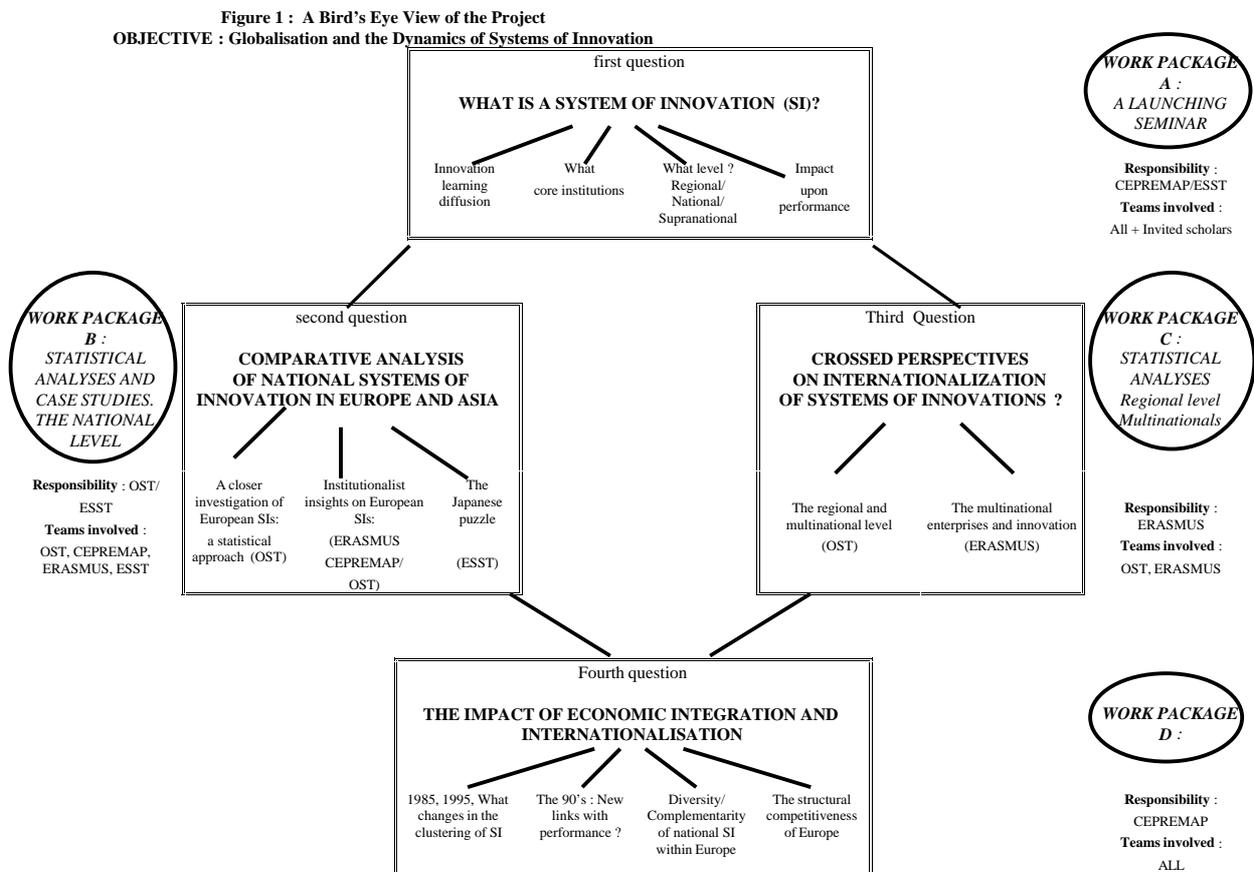
The objectives of the seminar and the main issues to be discussed.

Various answers have been given to these three issues. For simplicity sake and as an organisational device, the seminar will proceed by a stepwise discussion of the basic hypotheses of a research sponsored by a TSER program which is devoted to the investigation of the “Comparative dynamics of innovation systems: implications for S&T and other policies”, which associates various research centres across Europe (CEPREMAP and OST (Paris), ESST (Oslo), Rotterdam School of Management (Rotterdam)).

The seminar successively addressed the following issues :

1. The first question goes back to the central notion of this study: *what a system of innovation (SI) is?* How relevant is it to analyse them in terms of social system of innovation (SSI)?. This question is addressed to a broad community of specialists and asks: what a SI does, which institutions it involves, at what level it operates and finally how it performs.
2. The second question bears on the *diversity of national systems (SNI)* observed in Europe and how they fare compare to other very different systems such as the one of Japan.
3. The third question focuses on the working of SI at *specific levels*: not only the nations, but the regions and the multinational firms, looking for more information and scope on the conflicting issues that may arise at these levels. This is a distinctive feature of this project.
4. The fourth question then addresses the core issue: what is the impact of *economic integration and internationalisation* on national and regional systems of innovations.

Figure 1 recalls these four questions as well as the set of work packages attached to them and the teams involved and responsible. We detail hereafter the four operations.



The invited participants were asked to react to this research synopsis according to their own views and current hypotheses. No paper specially written for the seminar was required from the participants, but any previous or related publication is welcome, as a background paper to be distributed to the participants. The intensive seminar thus proposed to organise strong interactions among a limited group of scholars, which nevertheless are belonging to contrasted traditions and investigating different features of innovation systems.

### *List of participants*

<u>Name</u>	<u>Institution</u>
AMABLE Bruno	(INRA-CEPREMAP, Paris, France),
BARRE Rémi	(OST, Paris, France),
BEIJE Paul	(Erasmus, University of Rotterdam, The Netherlands)
BOEKHOLT Patries	(Technopolis - Erasmus, University of Rotterdam, The Netherlands)
CADIOU Yann	(CEPREMAP-OST, Paris, France)
DUNNING John	(Rutgers University, USA)
EDQUIST Charles	(Linkoping University, Sweden)
FAGERBERG Jan	(ESST, Oslo University, Norway)
GRØNNING Terje	(ESST, Oslo University, Norway)
PILAT Dirk	(OECD, Paris, France)
LUNDVALL Bengt Åke	(Aalborg University, Denmark),
MJØSET Lars	(Oslo University, Norway),
NARULA Rajneesh	(ESST, Oslo University, Norway),
PETIT Pascal	(CEPREMAP, Paris, France)
POLT Wolfgang	(OECD, and Forschungszentrum, Seibersdorf, Austria)
SMITH Keith	(STEP Group, Norway)
Van TULDER Robert	(Erasmus, University of Rotterdam, The Netherlands)

## **Social systems of innovation (SSI). B. Amable, CEPREMAP.**

**Discussants: B.A. Lundvall, K. Smith**

The presentation started out with the observation that the discrepancy between the scientific and technological capabilities of Europe on one side, and its economic performance on the other, constitutes the "European paradox", which presents a challenge to analysts as well as policy makers at both national and European Union levels.<sup>12</sup> The paradox raises questions such as:

- What are the roles played by macro-economic conditions, international monetary and trade rules, and research and innovation policies in fostering competitiveness?
- Is there a "best" configuration towards which the innovation systems should converge?
- How should the diversity of the European nations be treated in the making of a more and more integrated European space?
- Is there – or should there be – such a thing as a "European science and technology system" encompassing the national system?

The objective of the presentation was then to present theoretical and empirical analysis which would be helpful in addressing those questions. The basic hypothesis presented was that a variety of models co-exist among industrialised nations, progressively modified in the course of history through a long process of trial and error, resulting in path-dependence of the existing forms and a lack of convergence. The notion of social systems of innovation (SSI) was put forward and defined as a set of institutions, routines and structures that govern the innovation process and the diffusion of technical change in a context characterized by externalities and learning effects. A typology of the social systems of innovation of 12 industrialised countries was then realised, based on an empirical analysis, which led to the characterisation of four "productive models" embodying four kinds of SSIs. The dynamics and transformation of the productive models were finally discussed and the possibilities of complementarity presented in the form of alternative scenarios. In conclusion it was argued that the diversity of the European SSIs should be handled as such and turned into an asset for the 21st century through adequate national and European policies.

## **The dynamics of the SSIs in the EU: a quantitative attempt to introduce the regional and MNFs in the dynamics. R. Barré, OST.**

**Chair: R. Van Tulder**

**Discussant: J. Fagerberg**

## **Presentation of the TSER-funded project Strategic Analysis for European S&T Policy Intelligence.<sup>13</sup>**

The project aimed at characterising the dynamics of scientific and technological activities in the EU regions in their relationship to economic growth. GDP per capita, scientific publications and European patents per capita ("densities") measured at two dates for the 15 EU countries broken down into 445 "regions" formed the empirical basis of Part A of the research. In part B of the research regions were in addition characterised by the geography of their "technological linkages": each patent has its inventor, located in a certain region (region A), where the research has been done, and an assignee (owner, i.e. a firm which can be independent or be the subsidiary of another firm. In any case there is an ultimate firm (in terms of financial control) located in region A (local linkage) or in another region of the country (national linkage) or in another EU country (EU linkage), or outside the EU (extra-EU linkage). A description of the linkages of the regions was made, followed by a typology of the 445 EU regions in terms of their profile of technological linkages. Then the concentration of foreign technological linkages was analysed in terms of concentration and convergence and divergence among countries and regions. Finally the activities of the EU regions in terms of participation to the FP were analysed, relating these activities to their scientific and technological activities, in order to address – through another entry point -. the question of cohesion among EU regions.

## **Changes within the Japanese system of innovation: a preliminary framework for a qualitative analysis of some basic traits. T. Grønning, ESST, University of Oslo.**

**Chair: R. Van Tulder**

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<sup>12</sup> The Amable-presentation was based mainly on the unpublished manuscript by B. Amable, R. Barré and R. Boyer "Diversity, Coherence and Transformations of Innovation Systems".

<sup>13</sup> The Barré-presentation was based mainly on the report R. Barré, F. Laville & M. Zitt *The Dynamics of S&T Activities in the EU Regions*. Paris: O.S.T.

**Discussants: W. Polt, P. Petit**

Explained some preliminary ideas for how to approach the inclusion of changes in Japan while referring to recent theoretical work on institutions and innovation. Discussed how the concept of institutions is central within the systems of innovation (SI) kind of analytical approach to innovation issues, since the existence or absence of - as well as the character of - specific, existing institutions is being interpreted as potentially conducive vs obstructive to innovation processes. However, in parallel with the emergence of SI-approaches there has been a discussion debating 'new' vs 'old' institutionalism within the social sciences. This debate has hardly been mentioned within the SI-literature. Grønning argued for the necessity of being aware of the basic traits of this debate, while comparing the basic traits of the 'new' institutionalism with the usage of the concept of institutions within the systems of innovation-approaches, since the systems of innovation approach might thereby be enriched.<sup>14</sup>

**The case of multinational firms. R. van Tulder, Erasmus University, Rotterdam****Chair: B. Amable****Discussants: R Narula, J. Dunning**

Presented the basic structure of the analytical framework utilised within *The logic of international restructuring* (Winfried Ruigrok and Rob van Tulder, Routledge, 1995) as well as within more recent work and suggested possibilities for adaptations to the CDIS project.

**Current / recently finished research projects. B.A. Lundvall, Aalborg University.**

1. Demonstrated the usefulness of an approach that puts innovation and learning at the centre of the analysis. In doing so we find that systemic features that differ between countries are important in explaining differences in dynamic conduct and performance. I also try to indicate how differences between national systems of innovation include and reflect differences in the style of innovation. To better understand these styles and especially differences in how new knowledge is created, distributed and used is a key to establish a more satisfactory theoretical basis for the analysis of national innovation systems. Therefore it is a promising enterprise to combine the analysis of innovation systems with an analysis of innovation styles.<sup>15</sup>

2. Did in addition review the main points discussed at the *Aalborg High Level Workshop on innovation Systems and Innovation Policy*, May 11, 1998.

**Current / recently finished research projects. J. Dunning, Rutgers University.**

Concluded that the age of alliance capitalism and the maturation of the knowledge economy is demanding a reconfiguration in the role of each of the three main organising mechanisms in a market oriented economy, and, indeed in the very structure of capitalism itself. Such a reconfiguration is primarily a result, on the one hand, of a shift in the origins of wealth in most industrial societies from natural resources to created assets – and especially all forms of knowledge – and on the other, of the widening geographical spread of all kinds of value adding activity.<sup>16</sup>

**Current / recently finished research projects. R. Narula, ESST, University of Oslo.**

Presentation taking its point of departure in two works in progress,<sup>17</sup> where the first starts out with the observation that globalisation, alliance capitalism and R&D intensive value adding activities are "hallmarks" of economic activity within advanced industrial countries. National governments have responded to these changes by pursuing policies promoting "techno-nationalism" which includes fostering R&D investment by national champions. The study subsequently first inquires from the firm's perspective why they have an increasing propensity to undertake R&D alliances, with particular focus on international alliances. Secondly

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<sup>14</sup> The Grønning-presentation was in part based on "The concept of institutions within systems of innovation-approaches", paper to the *Thorstein Veblen Conference on Institutional Analysis of the Economy Today: Conceptual Cores, Analytical Applications and Challenges to Institutional Analysis*. Oslo, June 18-19, 1998.

<sup>15</sup> The Lundvall-presentation was based on "National Systems and National Styles of Innovation", paper presented at the Fourth International ASEAT Conference "Differences in 'styles' of technological innovation" Manchester, September 2-4, 1997.

<sup>16</sup> The Dunning-presentation was based on "The Changing Nature of Firms and Governments in a Knowledge-based Globalizing Economy", Carnegie Bosch Institute Working Paper 98-15.

<sup>17</sup> The Narula-presentation was based on R. Narukla & J.H. Dunning (forthcoming) "Explaining international R&D alliances and the role of governments" and R. Narula "Strategic technology alliances by European Firms since 1980: Questioning integration?".

the aim is to understand the role of governments in promoting and engaging in the generation and diffusion of intellectual capital in general, and in facilitating inter-firm technological alliances in particular. Thirdly the aim is to evaluate the efficacy of techno-nationalism in light of the welfare and social responsibilities of governments, particularly in an age of globalisation.

The second study evaluates the extent to which private, non-subsidised cooperative agreements in R&D by EU firms has evolved, paying particular attention to the extent to which economic integration may have influenced intra-EU activity relative to extra-EU agreements (i.e. EU-US and EU-Japan alliances) over the period 1980-1994. Essentially, EU firms' partnering habits reflect the need to seek strong partners regardless of nationality within a given industry, although intra-EU partnering enjoyed a brief popularity during the latter half of the 1980s.

**Current / recently finished research projects. C. Edquist, Linköping University.**

Presented highlights from the newly completed TSER-funded project ISE, such as its analytical handling of the relationship between institutions and organizations.<sup>18</sup>

The *Systems of Innovation (SI) approach* for understanding innovations in the economy stresses that firms do not normally innovate in isolation but in *interaction* with other organisational actors (other firms, universities, standard setting organisations, etc.) within the framework of existing institutional rules (laws, norms, technical standards, etc.). *Institutions are not organisations*. Rather, they constitute the *rules of the game* or *framework conditions* for interaction. In contrast, organisations are the entities (actors) that interact. From this perspective, innovation is a matter of *interactive learning*. This contrasts with the linear view of technological change, which places R&D at the beginning of a causal chain that ends in productivity growth and employment, mediated by innovation and diffusion. Innovation policies are generally aimed at learning, and support many different types of learning processes. We argue, however, that these policies should target *interactive learning* much more directly than is the case today. For example, public technology procurement policies could be used more systematically to shape patterns of user-producer interaction. The knowledge infrastructure (including universities and the system of intellectual property rights) could be used to develop R&D co-operation between organisations more fully, and so on. *Organisational change* and *institutional change* are important instruments for a policy-maker who wants to influence innovation processes. Institutions and organisations that are specifically created, changed, or abolished by policy-makers are, by definition, instruments of public policy. The relations between institutional and organisational changes are also crucial for innovation processes. Institutional and organisational design and performance should become a much more conscious part of innovation policy, especially when the relevant institutions and organisations are not directly concerned with innovation (such as corporate law) but influence innovations anyway.

To illustrate this last point, we can refer to the ISE research on corporate governance. Corporate governance is concerned with the institutions that influence the ways in which business corporations allocate resources and returns: regulation systems, ownership and control structures, tax policies, financial systems, and so on. The key to formulating appropriate corporate governance policies in the EU is an understanding of the social conditions that support the commitment of financial resources to, and the integration of people into, innovation processes. Our analysis of corporate governance proposes that government policy be designed so as to encourage strategic decision-making in the allocation of corporate resources and returns. Such decision-making processes should:

- \_ involve those who are engaged in innovation activities.
- \_ reallocate both people and money from existing enterprises to new ones that can engage in innovation activities.
- \_ encourage the integration of producers who have previously not been involved in innovation activities.

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<sup>18</sup> The Edquist-presentation was based on Charles Edquist, Leif Hommen, Björn Johnson, Tarmo Lemola, Franco Malerba, Thomas Reiss, and Keith Smith (1998) *The ISE Policy Statement –The Innovation Policy Implications of the ‘Innovation Systems and European Integration’ (ISE) Research Project*, report from a project funded by the Targeted Socio-Economic Research (TSER) programme of the European Commission (DG XII) under the Fourth Framework Programme, European Commission (Contract no. SOE1-CT95-1004, DGXII SOLS), co-ordinated by Professor Charles Edquist of the Systems of Innovation Research Programme (SIRP) at Linköping University (Sweden).

One consequence of the interdependent and non-linear view which characterises the SI approach is that it is natural to bring in demand as a determinant of innovation. A corollary of treating demand as an important determinant of innovation is a widening of the traditional view of innovation policy to include not only supply side instruments, but also demand-oriented instruments. Examples of demand-oriented instruments are government-designed institutions such as laws and regulations in the fields of consumer safety and environmental concerns. Another example is technology diffusion policy, including instruments affecting choices between alternatives and their use. A focus on demand also naturally leads to an emphasis on public technology procurement as an innovation policy instrument. Such procurement occurs when a public agency places an order for a product or system that does not (yet) exist, i.e. it involves innovation.

Some *institutions* are created *by design*, for example patent laws and some technical standards. Others have *evolved* spontaneously over extended periods of time, such as various kinds of social rules or habits, e.g. in co-operation between technology-using and technology-producing firms. Institutions designed by public agencies may constitute innovation policy instruments. For examples of the tension between designed and evolved institutions, we can refer to the ISE empirical work on public technology procurement as an innovation policy instrument. The findings indicate that, in Europe, there has often been a conflict between institutions designed by policy-makers and evolved ‘co-operative’ institutions concerning relations between buyers and sellers. The rules designed by policy-makers often promote anonymous market relations and ‘perfect competition’. The evolved institutions mean close interactive co-operation between procurers and suppliers, which is a necessary element in effective technology procurement. Public technology procurement *is* a matter of interaction between (public) procurers and potential suppliers, i.e. it is a matter of interaction between elements of a system of innovation. The point of departure is a perceived socio-economic problem or need (perhaps of an environmental or infrastructural nature) that is not solved or mitigated by private market actors. In other words, public technology procurement is a policy instrument working from the demand side. There are not many such instruments available. In Sweden, two cases of public technology procurement (high-voltage electrical transmission and electronic telecommunications switching equipment) have been quite successful. These cases led to radical technological breakthroughs which were crucial for the consolidation and international competitiveness of the supplying firms: Ericsson and ASEA/ABB. EU Procurement rules, rigorously applied, would have prevented such procurement processes from occurring. This is because they would have worked against the long-term co-operative relations between procurers and suppliers that led to the breakthroughs in these cases. To point to the tension between the EC procurement rules and the need to accommodate informal co-operation in the context of user-producer interaction related to technical change, is not to suggest a reversion to protectionist policies. It is rather to indicate that *too great an emphasis on ‘perfect competition’ can undermine competitiveness.*

The policy conclusion is that ‘perfect competition’ should not be enhanced at all costs. There is a subtle balance between co-operation and competition in processes of technical change. The issue is therefore how long-term user-producer relationships in processes of technical change can be allowed and supported without this leading to protectionism. This issue is not taken fully into account in existing EU procurement rules. The rules must allow for close interactive learning between procurers and suppliers. The relation between the procurer and the (potential) supplier(s) must certainly not be confined to arm’s-length market relationships. This has radical implications with regard to existing regulations at the European level which currently do not recognise the need for such interaction, except in a negative way. Present EU legislation merely *allows* such interaction to take place—and only in special cases. Under EU procurement legislation, collaboration between firms and public agencies aimed at the development of new technologies with the ostensible goal of increasing public benefit has only been tolerated as a ‘necessary evil’. Implicitly, it regards interaction between procurers and suppliers as an aberration—a deviation from the legalised norm of autonomous ‘market’ relationships. Accordingly, it has restricted both the fields of economic activity in which such interaction will be allowed to occur, and the circumstances under which it will be allowed to proceed. National rules must be compatible with EU procurement directives and therefore have the same character. In other words, possibilities for interactive learning have been diminished because of EU regulation. Hence, for the benefit of innovation, the regulations should be changed. In a positive way, *the regulations should be changed to encourage, stimulate, and spur interaction between procurers and suppliers in fields where public technology procurement is appropriate.* A committee should be appointed to investigate possible revisions to existing EU procurement rules in this direction. Institutions also play a very important role with respect to innovation processes by influencing the selection between technologies. Two empirical sub-projects ‘Procurement’ and ‘Technological Entry’—refer to technical standard setting as an institutional area where it is of crucial importance to make strategic selections. The example used by both is that of the NMT standard

in mobile telecommunications, which gave a competitive advantage to Finland and Sweden and crucially assisted Nokia and Ericsson in their entry into mobile telephony.

Early in the transition phase, when new technologies emerge, technical standards can be of great significance in influencing the content and speed of technological development. For many technologies, market forces will lead to the development of 'de facto' standards without the need for government intervention. In other cases, as in telecommunications, intervention by public (or semi-public) agencies may be needed to limit diversity in order to permit faster diffusion of a preferred technology. By limiting diversity, institutions also reduce uncertainty. Thus, standards can create a stable environment for investment and growth. However, they may also lead to lock-in situations.

**Current / recently finished research projects. W. Polt, D. Pilat, OECD.**

Highlights from OECD's Working Group on Innovation and Technology Policy (1998) *National Innovation Systems: Analytical Findings*:

1. Determining how governments can better harness technological change to the benefit of economic growth and social progress, and learn from each others experiences, requires understanding how changing patterns in technology diffusion and innovation affect the performance of firms and the economy in different national contexts. Productivity is the key to improving real income and competitiveness and is one of the most important yardsticks of industrial performance. Technological change can bring significant productivity gains and job creation when it is accompanied by organisational change and upgrading of skills. Innovative firms are therefore the main drivers of economic growth in a knowledge-based economy. The processes of innovation and technology diffusion are undergoing substantial changes, and national innovation and production systems are becoming more interdependent. Still, country-specific factors continue to shape firm-level innovation patterns and their impact on economic performance.

2. This report identifies the main distinctive features of national economies that have to be taken into account when evaluating policy challenges raised by the emergence of a knowledge-based economy:

- Inherited patterns of scientific, technological and industrial specialisation. The report provides empirical evidence on diverging national patterns of specialisation.
- Institutional profiles. The report shows important variations in the respective roles of the main actors in innovation processes (firms, public and private research organisations, and government) as well as marked differences across countries regarding the main policy-making institutions.
- Country size and level of development. The report devotes special attention to the specificities of national innovation systems in what are termed "catching-up economies", especially the need to build an indigenous science and technology base and to move from a strategy based on imitation to an innovation policy.
- Structures of knowledge interactions. The report analyses and compares national patterns of knowledge flows, among and between firms and non market institutions, and provides empirical evidence on the importance of labour mobility in the economy-wide diffusion of tacit knowledge.

3. Increasing the contribution of science and technology policy and infrastructure to national economic performance requires evaluating more carefully their impact on:

à Firm innovation capacity. The innovation capacities of a majority of firms, especially SMEs, are limited, and innovative firms vary in their level of competence. The report identifies the main firm-level barriers to innovativeness that government can help lower by facilitating the diffusion of best practice innovation management and diagnostic tools.

- Firm networking. The report synthesises new empirical studies which demonstrate that collaborative firms are more innovative than others; network relationships are durable and trust-based and increasingly involve knowledge-intensive service firms; and globalisation does not loosen but, on the contrary, often strengthens national networks.

- Innovative cluster formation. Clusters of innovative firms are emerging as drivers of growth and employment, by acting as magnets for new technology, skilled personnel and research investments. These clusters differ in the mechanisms of knowledge-sharing and transfer. The report discusses how a 'cluster approach' can be used for formulating and implementing technology and innovation policy.<sup>19</sup>

Current / recently finished research projects. K. Smith, STEP-group.

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<sup>19</sup> The presentation did in addition also refer to other recent works including e.g. *Technology, productivity and job creation*, note by secretary general for use at Council at Ministerial Level 27-28 April, 1998.

Smith presented a paper<sup>20</sup> which is concerned with the concept of the 'innovation system' and its policy implications. The paper is in three parts. The first discusses and overviews the recent literature on innovation systems, both theoretical and empirical; this is not a comprehensive literature survey but an overview of conceptual approaches in terms of the current 'state of the art'. The second part of the paper discusses explicit or implicit approaches to firm-level learning and technological knowledge, within this and related literature, and the implications for the understanding of innovation processes, focusing on the contrast between 'systems' models of learning and the concepts of knowledge which underpin the current 'mainstream' rationale for policy in this area. The third section discusses policy problems arising from this broad field of study, focusing on two broad issues: the rationale for policy intervention; and policy capabilities and policy 'knowledge bases'.

**Current / recently finished research projects. L. Mjoset, University of Oslo.**

Highlights from Mjøset's sub-study within the TSER-funded project 'Technology, Economic Integration and Social Cohesion'.

The post-war Western European welfare state, which matured since the 1960s, represent a major historical achievement: it has granted the broad masses of citizens' social rights and security at an unprecedented level. But just after these welfare states matured, since the early 1970s, most Western European countries have experienced a movement to higher levels of unemployment. A number of other worrying features of the Western European situation have been noted: higher rates of long term unemployment, an increasing volume of part-time work with little job protection, and an increasing number of people in precarious labour market positions. The trend is striking: With the exception of the UK (with its very restrictive statistical counting of unemployed persons), all the larger EU countries are now in the high unemployment group. Exceptions are getting more scarce: By the late 1990s, only the UK and Denmark — once in the high unemployment group — have been able to escape back to a medium level, and only Norway — once in the medium unemployment group — have been able to jump back to low unemployment. What part has the welfare state played in this development? In the following analysis, we explore the relationship between the welfare state and labour market developments, unemployment in particular. Our analysis relates potential welfare state/unemployment links to major processes of socio-economic transformation since the late 1960s. A brief sketch is given of how the problem has been treated within comparative analyses by economists and sociologists. In particular, the typology — most thoroughly elaborated in the work of Gösta Esping-Andersen — distinguishing a Nordic, a Continental European and a US pattern of welfare state/family/labour market-interaction is discussed. The typology is shown to be too crude.

This is shown in some detail for developments in the 1990s, especially for the case of the large Continental European countries. The typology gives no clear understanding of present short-term problems of unemployment. For such research purposes the members of the Continental European should be treated separately. The typology may, however, be relevant in the discussion of longer term scenarios focusing on how well prepared the Western European countries are to meet longer term challenges such as ageing, increasing female preferences for educational attainment, and changes in the family structure.

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<sup>20</sup> "Systems Approaches to Innovation: Some Policy Issues" submitted to the Commission in December, 1996, as part of *Innovation Systems and European Integration (ISE)*, a research project funded by the Targeted Socio-Economic Research (TSER) program of the European Commission (DG XII) under the Fourth Framework Program, European Commission (Contract no. SOE1-CT95-1004, DGXII SOLS), coordinated by Professor Charles Edquist of the Systems of Innovation Research Program (SIRP) at Linköping University (Sweden).

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### 7.3. List of Research reports

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7.3.1. List of research report from CEPREMAP

See Annex 7.3.1

7.3.2. List of research report from OST

See Annex 7.3.2

7.3.3. List of research report from Rotterdam School of Management

See Annex 7.3.3

7.3.4. List of research report from TIK

See Annex 7.3.4

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