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## *Policy and Innovation in Low-Tech — Knowledge Formation, Employment & Growth Contributions of the 'Old Economy' Industries in Europe*

## *PILOT*

FINAL REPORT

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## PILOT

## Final report

HPSE-CT-2002-00112


**Funded under the Key Action**
**'Improving the Socio-economic Knowledge Base' of FP5**

**DG Research**
**European Commission**

Issued in
January 2006



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Directorate-General for Research
2007 Citizen and Governance in a knowledge-based society EUR 23152 EN

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Luxembourg: Office for Official Publications of the European Communities, 2007

ISBN 978-92-79-07781-4



*Printed in Belgium*

PRINTED ON WHITE CHLORINE-FREE PAPER

## Preface

Within the Fifth Community RTD Framework Programme of the European Union (1998–2002), the Key Action 'Improving the Socio-economic Knowledge Base' had broad and ambitious objectives, namely: to improve our understanding of the structural changes taking place in European society, to identify ways of managing these changes and to promote the active involvement of European citizens in shaping their own futures. A further important aim was to mobilise the research communities in the social sciences and humanities at the European level and to provide scientific support to policies at various levels, with particular attention to EU policy fields.

This Key Action had a total budget of EUR 155 million and was implemented through three Calls for proposals. As a result, 185 projects involving more than 1 600 research teams from 38 countries have been selected for funding and have started their research between 1999 and 2002.

Most of these projects are now finalised and results are systematically published in the form of a Final Report.

The calls have addressed different but interrelated research themes which have contributed to the objectives outlined above. These themes can be grouped under a certain number of areas of policy relevance, each of which are addressed by a significant number of projects from a variety of perspectives.

These areas are the following:

- ***Societal trends and structural change***

16 projects, total investment of EUR 14.6 million, 164 teams

- ***Quality of life of European citizens***

5 projects, total investment of EUR 6.4 million, 36 teams

- ***European socio-economic models and challenges***

9 projects, total investment of EUR 9.3 million, 91 teams

- ***Social cohesion, migration and welfare***

30 projects, total investment of EUR 28 million, 249 teams

- ***Employment and changes in work***

18 projects, total investment of EUR 17.5 million, 149 teams

- ***Gender, participation and quality of life***

13 projects, total investment of EUR 12.3 million, 97 teams

- ***Dynamics of knowledge, generation and use***

8 projects, total investment of EUR 6.1 million, 77 teams

- ***Education, training and new forms of learning***

14 projects, total investment of EUR 12.9 million, 105 teams

- ***Economic development and dynamics***

22 projects, total investment of EUR 15.3 million, 134 teams

- ***Governance, democracy and citizenship***

28 projects; total investment of EUR 25.5 million, 233 teams

- ***Challenges from European enlargement***

13 projects, total investment of EUR 12.8 million, 116 teams

- ***Infrastructures to build the European research area***

9 projects, total investment of EUR 15.4 million, 74 teams

This publication contains the final report of the project 'Policy and Innovation in Low-Tech — Knowledge Formation, Employment & Growth Contributions of the 'Old Economy' Industries in Europe', whose work has primarily contributed to the area 'The challenge of socio-economic development models for Europe'.

The report contains information about the main scientific findings of PILOT and their policy implications. The research was carried out by thirteen teams over a period of three years, starting in December 2002.

The abstract and executive summary presented in this edition offer the reader an overview of the main scientific and policy conclusions, before the main body of the research provided in the other chapters of this report.

As the results of the projects financed under the Key Action become available to the scientific and policy communities, Priority 7 'Citizens and Governance in a knowledge based society' of the Sixth Framework Programme is building on the progress already made and aims at making a further contribution to the development of a European Research Area in the social sciences and the humanities.

I hope readers find the information in this publication both interesting and useful as well as clear evidence of the importance attached by the European Union to fostering research in the field of social sciences and the humanities.

J.-M. BAER,

Director

## Table of contents

**Acknowledgements**

The scientific members of the project consortium would like to thank their administrative colleagues and in particular Martina Höffmann and Katrin Hahn at the University of Dortmund for their competent and considerate work.

The PILOT consortiums as a whole would like to thank the people at the European Commission's Directorate-General for Research, in particular Heiko Prange-Gstöhl and Nikos Kastrinos, for their manifold and unbureaucratic support.

This paper is a report on work done by a team of more than twenty people (most of whom are listed in section VI. 1.Annex 1) over a period of three years and hence has more than one author. Some members of the team directly contributed texts to this particular document and it was the job of the scientific coordinator of the project to use these and other 'building blocks' to organise a coherent paper.

In particular, in preparing section III, I have relied on the work package reports and other PILOT papers written by Staffan Laestadius of KTH, Stockholm (section III 1.); Trond Einar Pedersen, NIFU STEP, Oslo (section III 2); Kevin Heanue, David Jacobson, both of Dublin City University, Klaus Schmierl, ISF, Munich, and Gerd Bender, Dortmund University (section III 3); Matthew Hancock, IpL, Bologna, based on papers by Francesco Garibaldo (IpL) and David Jacobson (section III 4); and Kevin Heanue and David Jacobson (section III 5; and section IV).

Paul Robertson read the entire report and made various suggestions that are incorporated in the final result.

GERD BENDER

Prepared by Gerd Bender, on behalf of the PILOT Consortium using contributions from F. Garibaldo, M. Hancock, K. Heanue, D. Jacobson, S. Laestadius, T. E. Pedersen and K. Schmierl.

**Abstract**

*The PILOT project comprised partners from nine European countries. The national research teams have conducted a series of case studies on non-research-intensive, so called low-tech companies in eleven countries, investigating their value chains and regional networks, and the policies that impact on these firms and on low-tech and medium-low-tech (LMT) sectors in general. A second thread of work has been quantitative analyses of the contributions of these industries to employment, growth and innovation in OECD countries. Finally, the members of the project made a number of conceptual advances.*

*Among the most important results are the following: The project established that most growth and employment in OECD countries still emanate from LMT industries. It provided ample evidence of the existence, and in many cases the crucial importance, of non-research based innovation. The analysis shows that innovativeness is based on a particular enabling configuration of resources that a company possesses rather than on excellence in R&D alone. In fact, PILOT found that significant innovation might occur in the absence of any activity that could be classed as R&D under commonly-used definitions. Internal organisational practices – knowledge management and personnel policy in particular – play a vital role for innovation in and the innovativeness of LMT firms, while network relations between companies and supportive social networks on a regional level are also important as they are resources for firm capabilities. The analysis also substantiates that interrelationships of mature LMT sectors on the one hand and young high-tech sectors on the other are of major importance for the innovativeness of industry in general.*

*In relation to policy, PILOT has provided evidence that there has been a bias in policy towards science-based innovation and high-tech industries. This is a problem because the relationship between R&D and high-tech on the one hand and economic success on the other is at best tentative. Efficient and sustainable policies to support innovativeness should therefore be non-discriminatory; that is to say, policy makers should be aware that "LMT actors" are an important segment of a country's innovation infrastructure.*

*On a more general level, PILOT's results lend support to a new understanding of the restructuring of the economic landscape of Europe in the early years of the 21st century. Europe's future does not appear likely to result in wholesale structural replacement of "old" sectors with "new" ones, or to a sweeping substitution of "old" technologies with "new" ones, but rather to lead to a continually changing blend of technologies of various vintages. This process of change is evolving as a restructuring of sectoral and*

*technological systems, transformed more from within than from without. It is not dominated by industrial activities for which competitive advantage, capability formation and economic change are generated by front line technological knowledge. Rather, it is dominated by what are often pejoratively termed low-tech and medium-low-tech industries. And it is unambiguously characterised by the continuous combination and re-combination of high and low-tech attributes.*

## I. EXECUTIVE SUMMARY

In the movement towards a knowledge based society in the European Union, the competence to generate, use and absorb new knowledge is increasingly viewed as critical for economic success and societal development. Against this background, the conventional wisdom sees high-tech, research-intensive and science-based industries as the key drivers of future economic prosperity. Such industries are regarded as the main source of highly sophisticated products that are not easily imitated elsewhere and, therefore, the policy conclusion is that high-cost industrialised countries should concentrate their efforts on promoting these industries. In this scenario, non-research-intensive, so-called low-tech and medium-low-tech (LMT) industries are deemed to offer little to enhance prospects for future growth, and as a result, they receive less explicit political attention and support. LMT sectors comprise for the most part mature industries such as the manufacture of household appliances, the food industry, the paper and print industry, the wood and furniture industry, the manufacture of metal products or the manufacture of simple plastic products.

Such sectors were the focus of the PILOT project, and a critique of the reasoning just outlined and of the unfavourable policy consequences that followed were its starting point. The main objective of the project has been to establish the role of low-tech and medium-low-tech industries in the knowledge based economy both empirically and conceptually, and to determine what part they played in innovativeness and innovation within countries and regions. Hence, the project's thread was twofold from the very beginning, with an intention to contribute to both innovation research and the knowledge base for innovation policy.

Since early 2003, the national research teams in the project have conducted case studies on LMT companies in eleven European countries (cf. section III 3.), on the value chains these firms are part of, on their regional networks (cf. section III 4.), and on the policies that impact on the firms and on LMT sectors in general (cf. sections III 5. and 4.). The results of this research have been thoroughly discussed in various project workshops. The analysis of LMT related policies was achieved through two levels of research activity. One level was that of policy makers in various policy institutions including industrial and development agencies, industry association, trades unions, municipal and regional authorities, national governments and EU agencies. Secondly, the policy research incorporated the results from the case studies in which decision-makers in the companies were asked to identify the nature and level of policies that affect their firms and industries most significantly.

This work has been complemented by quantitative analysis of the contributions of non-research-intensive industries to employment, growth and innovation in OECD countries (cf. section III 2.). In addition, conceptual issues were tackled. Among the results of the latter work are a suggested taxonomy that is better suited to catch the fundamental phenomena of the knowledge based economy than the established industrial classification system (III 1.) and the concept of "innovation enabling capabilities" which was designed to grasp preconditions of innovativeness on the level of an organisation (III 3.).

The project consortium comprised eleven research teams from nine European countries (Austria, Finland, Germany, Ireland, Italy, Norway, Poland, Spain and Sweden). The work was co-ordinated by the University of Dortmund, Chair of Industrial and Economic Sociology (UDTM.ESS.TS). The following points provide a brief summary of the project's main results.

- **Much growth and employment in OECD countries still emanate from LMT industries, and LMT companies are relevant sources of innovations in the economy (cf. III 2.).**

LMT industries in the OECD countries employ many more people than high-tech industries. Moreover, many firms in these industries are innovative and knowledge intensive without, by definition, engaging in R&D to any great extent. Thus, they provide a striking challenge to currently held notions about the sources of future industrial growth. Our analysis suggests that while new sectors emerge within the economy, and some sectors disappear, this does not account for the processes of growth which actually occur across the OECD. The growth trajectories of the advanced economies seem to rest as much on such sectors as engineering, food, wood products, and vehicles and so on, as they do on such sectors as ICT or biotech. Medium-low and low-tech industries have persisted over the past decades despite the claims that we are undergoing a kind of structural revolution.

In terms of industrial structure, change and growth, there is substantial variation across OECD countries when it comes to the shares of output and employment accounted for by high-tech industries – there are quite different sectoral mixes that persist over time. In this context we found no evidence of any direct linkage between technological intensity of the industrial structure and economic growth at the level of the economy as a whole. There is no simple relationship to the effect that the high-tech economies are also the high growth economies. This suggests that different economies can follow different routes to economic growth.

Countries play different roles in an economic system which is differentiated at the international level, and in which there is a division of labour among the highly developed economies.

These research findings show that growth is primarily based not on the creation of new sectors but on the internal transformation of sectors that already exist. Over-emphasising the role of high-tech activities ignores this major dimension of change in advanced economies. As a corollary, in order to ensure continued future growth prospects for advanced economies, policy-makers need to focus on the processes of innovation and creativity in firms in all sectors, not just high-tech firms.

- **Innovation policy can be more effective when it is based on a more comprehensive understanding of the relationship between R&D and innovation (cf. III 1.).**

The project has tried to address the issue of the appropriateness of currently used innovation indicators and the conceptualisation of innovation on which they are based. We argue that improvements can be made in their construction and use.

More generally, our findings on what goes on at the micro level of the firm aggregate to raise serious questions about the assumed relationship between R&D and innovation at the macro level of a country or region. The OECD classification of four industry clusters (high-tech, medium-high-tech, medium-low-tech, low-tech) is often falsely used to identify innovative and, hence, "relevant" sectors with the implicit understanding that high-tech is by definition innovative and low-tech is by definition not. Based on such a view, enormous innovation potentials escape attention. There are very many activities which may be classified as creative and innovative but which normally are not identified like that, for example architecture, software production, some consultancy and some restaurant work. To the extent that products are new, one can argue that they should be considered as innovations. As admitted in the Oslo Manual such innovations, which have no clear "technological height", are difficult to handle and are thus excluded from consideration.

Our research results, as reported in Sections III 1. to 5., suggest that as an alternative to – better: in addition to – R&D expenditures, analysts must use other indicators of innovativeness and of the general level of technology in an economy. Firms may be classified according to their:

- R&D intensity;

- design intensity;

- technological intensity;

- skill intensity (human capital orientation);

- innovation intensity;

- organisational innovativeness.

The basic assumption is that these indicators together will capture the bulk of creativity, explaining successful firms and industries and showing the variety in all economic sectors. Thus we argue that the adoption of a family of indicators rather than a composite indicator is a more appropriate way to improve on available taxonomies.

- **Innovativeness is based on a particular enabling configuration of resources that a company possesses rather than on excellence in R&D alone (cf. III 3.).**

What are the preconditions for innovativeness in general and in LMT companies in particular? PILOT research shows that R&D in the established sense is only one and not necessarily the most important prerequisite for the innovativeness of an *economy*. Furthermore, there are very many highly innovative *organisations* that are not engaged in R&D at all. Drawing on our case study research and the discussion in management sociology and economics on dynamic capabilities, the concept of "innovation enabling capabilities" (IEC) has been introduced. It is composed of the two dimensions of transformative and configurational capabilities. In the former case, the focus is on the enduring ability of an organisation to transform globally available general knowledge into locally specific knowledge and competences, while the latter case focuses on the enduring ability to synthesise novelty by creating new configurations of established knowledge, artefacts and actors.

The IEC concept aims at analysing the facilitating mechanisms and interdependencies between available resources and innovation outcomes of diverse kinds. There is, of course, a policy dimension too. The prevailing R&D-focused innovation policy instruments fail to address the deeper concerns and needs posed by the innovation activities of LMT companies. This is obviously of concern for the firms themselves that do not find sufficient support in the innovation policy system, but it is equally serious for policy makers in their attempts to increase the overall level of innovative activity in the economy.

With the IEC concept we introduce a tool that helps to identify organisational and cognitive preconditions (and deficits) for innovativeness on the level of an organisation and, thus, also helps to identify levers for sustainable innovation policy measures.

How can firms be encouraged to build up innovation capabilities? What roles could different actors play? How and at what level can the development of transformative and configurational capabilities be supported?

- **Organisation practices – knowledge management and personnel policy in particular – play a vital role for competitiveness and innovativeness of LMT companies (cf. III 3.).**

Contradicting another stereotype, PILOT research reveals that there is a variety of skill levels and forms of work organisation both among and within LMT firms in a range of sectors, rather than simply the low-skill, hierarchical model that is often assumed. There are indeed examples of a Taylorist regime but there are also more participative forms of work organisation with a low level of division of labour, flat hierarchies and a rather high overall qualification level.

It is not possible to identify a clear trend for the near future. The companies investigated during the PILOT project seem to follow one of two contradictory strategies. The first entails a (further) deskilling of the workforce in the immediate production process together with a concentration of competence at the white collar level (including engineers). The second strategy is directed at a general improvement of skills and qualifications.

The picture in regard to the use of advanced machinery is also complicated. We have found companies that deploy – and in few cases even develop – highly sophisticated machinery and process technologies, as well as those which still draw to a great extent on traditional manual labour.

Notwithstanding the vast variety of characteristics, structures and problems covered by the term “LMT company”, some general conclusions may be drawn on the basis of the case study analyses within PILOT. In many LMT companies, the bundle of skills workers need to possess is changing; craft based competences and skills are frequently (though not universally) becoming less important or obsolete while at the same time the ability to operate computer controlled machines is becoming more important. Currently, however, there is an absence of the provision of this type of hybrid qualification, a lacuna that contributes to recruitment problems. The lack of tailor-made curricula by education and training providers to address the gap in “crossbreed” qualifications exacerbates this problem.

In terms of policy, there is a need to examine ways to assist in providing access to the delivery of appropriate curricula either in-house or through some other mechanism to LMT firms. Those employees currently not usually participating in such further vocational training should be targeted. Perhaps especially in the first years of employment – as training in-house might represent a significant drain on the company – financial aid from the state or public agencies would facilitate the hiring and integration of more workers, especially young people.

- **Network relations between companies and supportive social networks on a regional level are of great and growing importance as resources for firm capabilities (cf. III 4.).**

Network embeddedness in various forms is becoming increasingly important for the capacity of LMT industries to act, given the growing challenges of the world market and globalisation. For example, cooperation in delivering more complex products and services to the market can be a very useful means to reinforce the position of LMT companies in general and of small or medium sized ones in particular.

These kinds of processes cannot be simply planned from above, but they need policies, at least, to ease the start-up process and increase the chance of long run sustainability. Experience from the PILOT project (and others) shows that the presence of a dense network of local institutions favouring knowledge circulation can facilitate these processes. This does not imply that the only scale for circulating knowledge among low-tech and medium-low-tech SMEs is the local or national. There are also examples of international circulation. The point is that there is a big difference as to whether the transfer comes from within a corporate scheme, from within a sub-supplier relationship, through taking advantage of institutional aid, or because of a cooperative scheme. In the last two cases the capacity of low-tech and medium-low-tech SMEs to exploit knowledge resources on their own is likely to develop with time and it is probable that some of this knowledge will spill over to other firms.

The policy problem is, therefore, to support building innovation-enabling capabilities for these companies to access knowledge resources in a critical and selective way. Such policies can also be implemented through networking. Shared facilities for product innovation or a policy coalition lobbying for particular policies, for instance specific vocational policies to strengthen the labour market, are examples of this.

- **Interrelationships of low-tech and high-tech sectors in an economy are of major importance for the innovativeness of industry in general (cf. III 2.).**

The project findings also emphasise that future industrial development in Europe does not depend on making a choice between high-tech and LMT industries. Rather, all these sectors are inextricably linked. In particular, low-tech and medium-low-tech industries are crucially important as customers of high-tech sectors in developed economies. This relationship means that the continued viability of the high-tech sector is inevitably linked to the on-going vitality of LMT industries, a symbiotic relationship that is often overlooked.

**Policy conclusion (cf. III 5. and 4.)**

In spite of the difficult overall economic situation of low-tech and medium-low-tech industries and the challenges of globalisation and growing competition, the future prospects of many LMT sectors and companies are not bad or may even be bright, depending on some structural conditions. Thisholds true for companies whose specific competencies cannot easily be copied by potential competitors; for firms that are active in markets where geographical and social proximity is a competitive advantage; and finally for companies that are able to absorb distributed knowledge (be it scientific or of any other type) and to employ up-to-date process technologies systematically and efficiently.

These conditions are not given for all LMT companies, and it is likewise true that not all companies in Europe are able to develop in this direction or really use structural conditions of this type in a competitive way when they face them. But there is no reason to believe that LMT companies are, in principle, less likely to face the challenge than research-intensive firms are.

What separates successful companies from others in the long run is the ability to innovate. And innovativeness is by no means an issue only for those with a high R&D budget. Hence, non-discriminatory support of innovativeness is a major policy topic. Our research findings lead to a number of problems concerning innovation policy in the low-tech and medium-low-tech sectors. Several policy issues should be highlighted.

- First, there is little if any awareness of innovation-supporting policies other than focusing on R&D.

- Second, it is an important policy task to devise measures and to support activities which aim at improving the knowledge base and the capabilities of low-tech and medium-low-tech companies.

- Third, policies should focus on the development of firm capabilities to meet the demands of cross-company co-operation with corresponding channels of communication, gateways and personnel responsibilities.

- Fourth, policies should encourage both the generation of knowledge and its diffusion between low-tech and high-tech sectors, and they should also promote stronger interrelationships between the sectors.

These considerations should also lead to a new understanding of the restructuring of the economic landscape of Europe in the early years of the 21$^{st}$ century. This future does not appear to foretoken wholesale structural replacement of "old" sectors with "new" ones, or a substitution of "old" technologies with "new" ones, so much as a continually changing blend of technologies of various vintages. This process of change is evolving as a restructuring of sectoral and technological systems, transformed more from within than from without. It is not dominated by industrial activities for which competitive advantage, capability formation and economic change are generated by front line technological knowledge. Rather, it is dominated by what are often pejoratively termed low-tech and medium-low-tech industries. And it is unambiguously characterised by the continuous combination and re-combination of high and low-tech attributes.

## II. BACKGROUND AND OBJECTIVES OF THE PROJECT

Policy makers and scholars often contend that industrialised nations are currently undergoing a fundamental transformation into knowledge-based societies. The competence to generate and utilise new knowledge is seen as a decisive factor for both economic success and societal progress in this modern era. This argument is accompanied by a firm belief that in the current situation the improvement of research-intensive high-tech industries is the key to increasing overall welfare. Correspondingly, so called low-tech sectors, mature and – compared to promising young branches such as biotech or nanotech – rather mundane industries are presented as being less important as agents for change in major industrialised countries.

The validity of the underlying logic of this argument depends simply on whether it is posed reactively, describing the need for science-based innovation as a necessary answer to constraints imposed by globalisation, or proactively, as a world-wide development model. It is based on the view that due to their high cost levels – caused mainly by established social and ecological standards and relatively high wages – the wealthy nations can only be competitive when they produce highly sophisticated high value-added products that cannot easily be imitated elsewhere. And these are, the reasoning continues, research-intensive goods that can only be created with a high level of scientific knowledge and expertise. Because information and learning processes diffuse ever more rapidly in the globalised world, there is constant pressure on the industries in the high-cost countries to innovate on a continual basis. Hence, policy makers in the European Union as a whole and its member states are often advised to focus on high-tech manufacturing and high-tech service industries and not waste money, time and attention on pre-21st century businesses.

A critique of this widely held belief was the starting point of the PILOT project: The argument in favour of high-tech science-based growth conjures away the role of low-tech industries in the structural changes currently underway in advanced economies. However, many of the processes we witness today in the European Union, both in the old and the new member countries, are based on developments outside the realm of high-tech. Non-research-intensive industries are – and will be for the foreseeable future – important not only for employment but also for growth and knowledge formation. The main objective of the PILOT project has been to substantiate this hypothesis by identifying both the importance of low-tech industries in a prosperous knowledge based economy in Europe, and the foundations of innovativeness on the organisational level in those industries.

## III. SCIENTIFIC DESCRIPTION OF PROJECT RESULTS AND METHODOLOGY

The work of the PILOT project focussed on a wide range of topics and issues and accordingly used a variety of different methods. On the one hand, conceptual and taxonomic issues were tackled (cf. III 1.). Work was also devoted to an empirical investigation of the role and function of low-tech and medium-low-tech (LMT) industries for economic growth and, more generally, to a statistical analysis of the extent to which growth is based on innovation (cf. III 2.). On the other hand, LMT companies and interactions between such companies were scrutinised by means of case study work. The core of this part of the project was a series of intensive company case studies in ten countries across Europe (cf. III 3.). The main emphasis was put on their use of technologies, on patterns of innovation and knowledge creation as well as on the importance of developing formal skills and qualifications for the firms' competitiveness and innovativeness. Other issues investigated are the collaborative behaviour of firms along value chains and the degree to which they are regionally "embedded" (III 4.). All these investigations also tried to identify the impact of innovation and industrial policies on the development of LMT firms and sectors (cf. III 5.). In addition to this, one work package was dedicated to investigating the policy issue from the "producer side" by analysing policy documents and interviewing policy makers on levels ranging from regional to the EU as a whole.

### 1. The Taxonomy Issue

One of the core conceptual questions of the PILOT project was the issue of a taxonomy of innovativeness. The reason is obvious: the "technology level language" created through the taxonomy introduced and modified by the OECD several decades ago has shaped the data acquisition routines as well as policy behaviour and rhetoric. It was consequently necessary to analyse not only the existing taxonomy in itself and/or create an alternative, but also to analyse how taxonomies are created and their roles in general.

The term taxonomy, although often used interchangeably with typology, is normally used for the classification of empirical entities. In short, typologies are normally conceptual and taxonomies are empirical, although the distinction is far from easy to uphold in practical analytical work. In this report we normally use the term taxonomy, primarily because the discussion is strongly related to empirical entities. The creation of a *taxonomy* or *typology* like the sexual system of Linneaus, the periodic table of the elements or the European Classification of Economic Activities (NACE) may be looked upon as a *communicative action*.

The intentions of those who participate in this process may differ depending on their knowledge interests which are very likely to affect their participation in the taxonomy creation process.

In general taxonomies facilitate communication because they create a "common understanding" between the stakeholders – i.e. those who have practical and scientific interests – in the field in question. But they also facilitate cognition of this knowledge field. The taxonomy may be compared to shorthand writing because it provides essential information in compressed form.

Communicative actions, such as the creation of taxonomies, are purposive activities and thus *normative*. The creator of a taxonomy has – or takes – the privilege of setting basic features of the agenda for the discourse which follows. Taxonomies like the periodic system basically have no other explicit intention than bringing order into the science or discourse in question, and that is done by reducing a large set of phenomena to a much smaller set of classes of phenomena which may facilitate analysis and open a path for new the way for discoveries.

Those taxonomies labelled *indicators* are usually by intent more normative than just directing further analytic work. The history of indicators – social as well as technological ones – has been to provide input into policy processes. The essential requirement of a taxonomy that is needed to make it useful – and thus sustainable – is that it is convincing enough to obtain *legitimacy* among relevant stakeholders, i.e. within the relevant community. This may be reached if the taxonomy contributes to economising communication and knowledge formation processes within a defined domain. This looks like an *efficiency criterion*, but it is in fact more than that. It also creates a model or pattern which limits and directs further search and policy activities. The taxonomy may, for example, provide cognitive incentives in searching for missing links, as has been the case in the history of the periodic system (Emsley 1998).[1]

Five criteria may be identified which – although related – contribute to the legitimisation process and thus to the survival capability of a taxonomy: a) simplicity, b) reliability, c) relevance, d) adaptability and, finally e) community creation. These are all of relevance for the discourse on technology level taxonomies

a) Taxonomies must, first of all, be reasonably *simple* to be efficient – a well known problem in the art of creating correspondence between maps and the reality they are supposed to capture. The most simple taxonomies are one dimensional

[1] In this respect a taxonomy has obviously some resemblance to Kuhn's (1962) paradigm.

ones of which the OECD technology level classification is a good illustration. Best known among the two dimensional ones is the matrix based periodic system which provides significant efficiency in communicating the structure of the elements. The complexity increases rapidly for higher order taxonomies, thus eroding the chances of achieving legitimacy.

b) *Reliability* here refers to how reliably data which are fed into the taxonomy can be identified, collected, transformed and presented. In short, constructing taxonomies which cannot be furnished with reliable data should be avoided. This problem is highly relevant in connection to science and technology (S&T) indicators. In spite of the detailed character of the Frascati and Oslo manuals (OECD 2002a and 1997) it is far from obvious that data sources – firms, professions, industries or nations – identify R&D and innovative activities similarly in practice.

This reliability problem may be significant. There are large differences in recorded innovativeness between sectors/industries which recruit similar professions and have high densities of academics. There are also several activities – especially in highly skilled service sectors such as knowledge intensive business services (KIBS) – which may be classified as creative and innovative but which normally are not identified like that. Other examples include architecture, software production, some types of consultancy and some restaurant work. To the extent their products are new and/or unique, it can be argued that they should be considered as innovations. The Oslo Manual explicitly excludes such innovations, which have no clear "technological height", because they are too difficult to handle.

In connection with the problems of identifying *what* activities to classify as innovative, we have the problem of how to identify the *localisation* of innovative activities. As will be discussed below, it is far from obvious where in a plant, firm, network, production chain, global corporation or system the essential innovative (value creating) activities take place and what activities to include in the relevant knowledge (or capability) formation process. The network character of industrial activity complicates the world for taxonomers. The globalisation of industrial activities adds still more dimensions to the construction of taxonomies and complicates their use in international comparative analyses.

c) The *relevance* criterion must be measured against the intentions behind the taxonomy. As regards the high-tech/low-tech taxonomy we may identify a general more or less explicit assumption that this taxonomy has relevance for economic growth.

If overall economic growth is the *raison d'être*, the recent world wide decline of ICT industries dramatically changes the relevance of the evaluation of high-tech sectors so dominant in the late 1990s.

In fact, recent economic history is full of examples of rapidly growing non-high-tech firms and sectors. In only two OECD countries do the so called high-tech manufacturing sectors contribute to more than 4 percent of value added. The first is Finland where, due to the Nokia phenomenon, 5.25 percent of value added (2001) originated in high-tech manufacturing. The second country is Ireland where, reflecting the Celtic Tiger phenomenon, 8.6 percent of value added (1999) was in manufacturing classified as high-tech (OECD 2004). Not even in the USA has the high-tech sector managed to exceed the 4 percent level more than once (1984) during the last two decades.

Even when leaving the growth perspective aside and focusing on knowledge formation and creation of industrial capabilities it may be asked firstly, to what extent the one dimensional strong focus on R&D input is relevant as an indicator of technology sophistication; and secondly, to what extent there are reasons to assume that the results may be related to a highly aggregated industry classification.

As regards the relevance of S&T indicators, the long and far from obvious chain between input (of science and technology) and industrial output should also be given special attention. This includes the problem of what kind of product emerges from the R&D process. Although science of relevance for Nobel Prizes is related to knowledge new to mankind, this is far from relevant for most knowledge formation processes taking place in society. Much R&D activity – confining ourselves to that segment of knowledge formation – to a large extent produces human capital useful for individual career planning, for acquisition processes, for business intelligence, and for the local absorption of technology developed elsewhere.

There is also a duration phenomenon the reinforces the question of relevance. The very long duration between scientific discovery and industrial application that prevails in many cases suggests that this relationship, if it exists as is normally assumed in the linear model of science and technology, is so complex that a policy model using science (R&D) to influence growth would be a very blunt tool.

In short it may be concluded that there are so many still undetected creative possibilities to transform the vast *stock* of "general" knowledge (episteme) into "useful" knowledge (techne) that it is far from obvious that commercial successes will be based on the recent *flow* of scientific breakthroughs. Recent developments in biotechnology may modify that picture, but biotech is still not a rapidly expanding industry. This indirect relationship is also, basically, the message in the chain-linked model on innovation posited by Kline and Rosenberg (1986).

Several analysts have questioned whether the traditional industrial classification system is a relevant base for analyses of innovation and knowledge formation processes. Even within industries which decline absolutely or relatively there may be significant groups of firms and plants which grow, innovate, and use advanced technologies etc. Due to the pervasiveness of information and communication technologies (ICT), many firms and/or sectors of industries have undergone dramatic transformations incorporating important knowledge formation processes. Although sometimes small, within the framework of declining large industries these niches may be more important than emerging high-tech industries for the economy as a whole. "Low-tech industry" may thus e.g. be a less relevant concept than the "low-tech firm". One means to create relevance from this perspective is to avoid industrial categories and only consider the technological profile of firms. Assemblers of refrigerators may thus be classified in the same category as those who assemble computers if they utilise the same automation technology.

At least one other problem may be related to the question of relevance. There is no a priori reason to assume a close connection between levels of technology (or technological height, however defined) and usefulness for mankind. The standard illustration to this argument is the container: low technological height, probably never captured in the R&D or innovation statistics – and extremely useful.

d) The legitimacy of a taxonomy may be upheld if it can *adapt* to new circumstances and accommodate new kinds of information. In short, we may discriminate between new discoveries of hitherto hidden elements in a (basically) static system and new facts which develop as a consequence of transformations and evolution occurring within the system.

Using the industrial classification to illustrate the adaptation to a changing system, we may identify two slightly different forms of evolution in the industrial system. *Transformation* of industries due to generic technologies may permeate old industries and techniques and also cause radical shifts of technology. Secondly, *maturing processes* in "new" industries may develop into phases of mass production. The way ICT related activities have been accommodated into the existing industrial classification system may illustrate the adaptiveness problems related to both of these processes.

To begin, ICT – normally supposed to be among the most high-tech of activities – is not identified as a coherent technology or business area within the NACE system of industrial classification. Although the manufacture of computers is included, the taxonomy is still mainly related to a pre-electronic world and it is far from obvious how to identify an ICT-sector (for details cf. Laestadius, 2005a).

Furthermore, significant parts of ICT activities take place in firms which are classified as services. Consequently we may add several service industries on the four digit level if our ambition is to cover the whole ICT sector. The OECD work on what sectors to include and what to exclude is far from convincing and also connected with severe theoretical problems (cf. Laestadius 2005a).

Some of this problem may be solved with better "resolution" in the statistics, e.g. through introducing a common fifth digit level in international data acquisition as already occurs in many national statistical systems. There are already problems on the four digit level, however. As an inheritence from the second industrial revolution, the manufacturing section contains 274 four-digit classes in the NACE (Rev.1.1) system while the complexity of industrially related services is represented by just a few classes (especially if those related to trade, real estate and legal activities are excluded). Industrial design is not explicitly identified at all in the NACE or ISIC systems; all architectural and engineering activities are classified in one entry (NACE 7420).

Although adding new digit levels to the existing ones may contribute to increased adaptiveness as regards arranging new aggregates as industries and technologies evolve, the outcome may be lost simplicity and reliability. Data providers (≈ firms) may not co-operate reliably. Firms organise their activities without regard to industrial taxonomies. Many of them are multi-technological in character and may not be able or willing to break down their activities into very elementary statistics. The present OECD classification of the ICT sector based on rearranging four-digit level ISIC data (OECD 2002b) may illustrate that, as shown above, that adaptation to new circumstances is not without problems.

e) As for the *community creation* criterion it may be argued that the S&T paradigm, and industrial taxonomies based on S&T indicators, maintain their strong position because most participants in this discourse have similar interests. This may be analysed from a perspective of power networks and policy segmentation; from a knowledge interest perspective or from an epistemological perspective. These approaches share a family resemblance, although with different emphases in political science, sociology and epistemology.

Following the first track, we may identify a set of institutionalised actors within the same segment of the policy arena and connected in more or less dense networks through similar economic and/or institutional interests and a common sector mentality among its professionals. Obviously international and national authorities for science, technology and industry policy as well as research groups/institutions and consultancy firms devoted to this policy arena belong to this network. Several high-tech firms and organisations may be added to the list.

The knowledge interest perspective is sociological in origin and concludes that this S&T policy arena has a strong momentum of its own because the academic community as a whole obviously benefits from strong S&T policy efforts – not the least through their research grants. Many innovation theorists have made their careers and received their positions in academia, as well as in policy institutions, thanks to the paradigm connecting science and technology with innovations. It may be argued that this field of work has contributed significantly to the relatively strong position of the community of neo-Schumpeterian inspired innovation analysts. Politicians and policy makers who are eager to stimulate economic growth are convinced that it is seldom wrong (although not necessarily efficient) to give money to R&D in the name of economic growth.

The epistemological track is not independent from the others but focuses on the cognitive processes and the creation of a common understanding. The concept "S&T paradigm" used here denotes a set of beliefs shared among important and large groups of academically trained individuals. Whether true or not, this paradigm – or thought world – conditions problem solving activities and search processes; implicitly it defines the arena and agenda for cognition activities.

It may be argued that, with the extension of the innovation concept from narrow scientific and technological domains into new areas of knowledge formation, "innovation" becomes a fuzzy concept as soon as it is supposed to become operational, testable and/or discriminated from something "non-innovative". Although the original Schumpeterian innovation concept had a clear pedagogical message in focusing on change rather than the "circular flow of economic life", the micro oriented analyst faces problems in deciding on what kind of changes should qualify as innovations and what kinds should not (cf. Laestadius 2005b).

### 1.1. A New Family of Indicators

The revisions of the Oslo Manual and the new varieties of the CIS add new dimensions of change to the old ones to make the concept of innovation more complete and answer the criticism directed at the concept (cf. CIS 2004). Innovations in services are included or considered to be included, as are non-technological changes and design. Investments in human capital are included (as indirect innovations) etc. As is clearly analysed by Foray (1999), there are many dimensions missing in our understanding of the knowledge base of society. A problem, of course, is whether they all must be counted as innovations to explain economic growth. In short, the adding of new spheres of innovation concepts may add new complexities to the question of how to create taxonomies based on an ever widening innovation concept.

An important aim of PILOT was to search for a new system of indicators. The existing taxonomy on technology levels for industrial sectors is one dimensional and based primarily on two pillars of data:

- Industrial statistics according to The International Standardised Industrial Classification scheme (ISIC);[2]

- R&D data as collected all over the OECD area according to a standardised system for classification (the Frascati Manual: OECD 2002a).

The collection and classification of data also relates to dominant UN and EU standards on national accounts, industry and product classification. The list of high-tech, medium-high, medium-low and low-tech industries published by the OECD in its present form contains – depending on the method of aggregation – twenty to twenty-seven manufacturing industries identified on two to four digit levels according to ISIC Rev.3. The classification is robust in relation to the two different, although R&D related, sorting mechanisms used: direct R&D as related to production and to value. This is a direct implementation of the linear model on science and technological development. Recorded R&D input is the main ranking principle. The conceptual relation between "science" and "R&D" is not explicit.

The starting point in the search for a new system of indicators within PILOT was the original Schumpeterian one that involves identifying a broad innovation concept including all forms of diversity creation (*creative combinations*) which may contribute to profitability and thus to value added.

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[2] Recently ISIC, Rev.3 (NACE Rev.1 in European statistics) has been substituted for Rev.2 (cf. OECD 2001, annex 1).

The *creativity* concept is far from easy to define or to make operational. An exact definition of creativity is, however, not necessary in this context. Here the focus is on identifying what may be called the *creation of capabilities*, significant parts of which may be labelled knowledge formation processes. As shown by Faulkner (1994), knowledge formation related to industrial innovation is far wider than what is normally included in R&D; the distinction between knowledge, related to design practice, and knowledge related to experimental R&D is of special interest. Design in different forms is also the core activity the chain-linked innovation model introduced by Kline and Rosenberg (1986). PILOT has also contributed to the development of the resource based theory of the firm and the dynamics capabilities approach to the analyses of knowledge formation processes and innovation (cf. section III 3.2. below).

Explicitly including *a design concept* into the analysis of innovative activities does not immediately simplify analytical work. In short, the discourse includes definitions focusing on aesthetics (adding aesthetic measures – or even functions – to objects) as well as focusing on the creation of the object itself (roughly "engineering"). The aim, or the task, of the design process is to create *fitness*. From this perspective, the design process may be looked upon as a *synthesising activity*, a creative problem solving act, where different fields of knowledge and sub systems are modified and integrated into a new entity – a physical or virtual artefact. This is also the position taken by Simon (1996) who explicitly argues that "everyone designs who devises courses of action aimed at changing existing situations into preferred ones". The activities involved may be characterised as rational, as innovative and as artistic, the relative importance of which may depend on the designer herself as well as her task.

A broad design concept, ranging from "adding aesthetics to the object" to "creating the object itself", complicates the dominant definition of innovations in general and of R&D in particular. Explicitly adding design as a category in innovation related typologies may necessitate a redefinition of R&D as it is presently identified in the Frascati Manual (OECD 2002a). In that manual, "D" stands for "experimental development". The relation of that concept to design (which is not explicitly defined) is discussed in several places, and the report concludes that the bulk of industrial design activities should be excluded from "R&D". It may, however be argued that good design to a large extent is experimental in its character. Thus we may argue that some experimental activities may be classified as design as well as R&D in a revised typology. As a by-product, we may obtain a somewhat more precise – or at least narrow – R&D concept because an independent definition of a design concept will include parts of what hitherto has been included in the "D" part of R&D. It may even be argued that most of the intentional creation of artefacts that characterises engineering should be included in the design concept rather than in the (experimental) R&D concept.

Introducing design will also affect the innovation concept presently used in the Oslo Manual (OECD 1997). The implication of the intentional focus in the Oslo Manual on technological product and process innovations (new at least to the firm) is that much design activity is excluded. "Technological" in the vocabulary of the Oslo Manual relates to the "objective" performance of products or processes thus relegating "subjective" performance related activities to the non-innovation realm. Adding a "design category" to "R&D" and "innovation" will, therefore, significantly increase our ability to capture industrial creativity although parts of what will be captured in the "design net" will be reallocated from what is already captured in the "R&D (or Frascati) net" or in the "innovation (or Oslo) net". Design data may well be collected in the same way as R&D and CIS data are collected today.

This simple widening of the innovation concept and redefinition of the "D" in R&D may impact on the classification of firms as well as of some industries. The impact on industry level should, however, not be overemphasised. Variety also seems to take place among firms within given industries.

It is possible to go further along this line although that may necessitate survey data collected in processes similar to the present CIS work. Inspired by Baldwin and Gellatly (1998 and 1999) among others, we developed a system with several indicators rather than one. Baldwin and Gellatly introduced a set of three indicators: *innovation competencies*, *technological competencies* and *skills* (human capital development), respectively.

The details of the variables in their approach are of less importance than their approach as a whole. Only the first indicator (innovation competence) is similar to the traditional innovation concept. The second one – technological competence – has no explicit connection to innovation at all but may be looked upon as related to a capability approach. This indicator identifies competencies in developing, importing, acquiring, purchasing and integrating new technologies in their processes. The third indicator in the Baldwin and Gellatly system focuses on human capital development, on the creation of skills, etc. We argue that an indicator like this[3] may catch the professionalism and skill-based customised activities which may make KIBS firms successful even if they do not innovate in a traditional sense.

[3] This searching for a skills-related indicator is fully in line with ambitions within the European Trend Chart on Innovation work.

Combining the Baldwin and Gellatly approach with the arguments from Faulkner and Kline and Rosenberg opens the way for a system with six indicators (cf. Laestadius et al. 2006 for more details). Firms may be classified according to their:

- R&D intensity;
- design intensity;
- technological intensity;
- skill intensity (human capital orientation);
- innovation intensity;
- organisational innovativeness[4].

The sixth indicator is perhaps somewhat less obvious than the others. The empirical results from the PILOT case studies, however, indicate that many of the successful low-tech firms have developed advanced logistical capabilities; capabilities which sometimes seem to be part of their core competencies (cf. III 3.2. below). There may thus be a strong case for including organisational skills/creativity as a sixth indicator rather than including it in the innovation intensity indicator.

These indicators may together make up a profile for the individual firm and/or for an aggregate of firms, e.g. an industry or an aggregate of different industries (such as the "ICT-sector" or the "technological system for pulp and paper"). They may require different sets of questions or data. The R&D intensity indicator is probably the most obvious: we may here stick to a revised and, as mentioned above, a more narrow version of the Frascati manual. As regards design intensity, we may include a broad design concept including parts of what hitherto has been included in "experimental development". As a result of that reallocation of design activities, R&D intensity will, ceteris paribus, decline in the statistics. In addition, the broadening of the design concept may have consequences for what aspects should be included in the new measure of innovation intensity and thus have some impact on the further revisions of the Oslo Manual (OECD 1997).

This system of indicators is not a typology of the classical kind as discussed by Bailey (1994) forming a conceptual world which is exhaustive or exclusive. We do not have to assume that these indicators are the only valid ones. Nor do we have to assume that

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[4] This family of indicators is tested with data from Norway in Laestadius et al. 2006.

firms or industries are either "R&D intensive" or "Design intensive"; individual firms may score high (or low) in all or one of the indicators above. The basic assumption is that these indicators together will capture the bulk of creativity, denoting successful firms and industries and showing the *variety* across all economic sectors.

The six entries above are not even necessarily exclusively defined. Some data collected for the formulation of "design intensity" may be similar or identical to those needed for specifying "technology intensity". Purchasing a design solution to a process from a consultant, for example, may be reported as acquisition of design as well as captured as integrating foreign technology with a firm's own processes. And parts of R&D activities may, depending on how innovation intensity is defined, be included also in the innovation intensity indicator.

Obviously there are to main paths two follow in future work. We may accept this as a *family of indicators* telling different stories about the same phenomenon but not susceptible to aggregation. Alternatively, we may make the indicators totally exclusive – i.e. locating all relevant activities to one and only one of the indices above – thus making it possible to aggregate them also to one single *composite indicator*. If overlaps are small, these may be neglected in the aggregating exercises.

The primary arguments for the construction of composite indicators – of which the already existing European Innovation Scoreboard, the Summary Innovation Index (SII) and Innovation Sector Index (ISI) are good illustrations (see ETCI 2004a and 2004b; EC 2004) – are to strive for simplicity and also, perhaps, for community creation (cf. Laestadius 2005b). As regards simplicity, one-dimensional indicators like the OECD high-tech/low-tech indicator have obvious pedagogical advantages: people remember them, react to them and (at least believe that) they can identify the meaning of them. As regards community creation, it may be argued that a simple one dimensional indicator with related typology/taxonomy can be identified as a focal point for orchestrated political action: we can all unite on transforming Europe into a high-tech knowledge based economy.

There are, however, strong arguments favouring a family of related indicators rather than focusing on a composite solution. From a data acquisition point of view the problem is probably non-existent. A reasonably disaggregated data collection can serve as a base for several different indicators. The basic argument is related to *the need to capture the variety as regards creativity* which may exist between firms within different industries and countries. Just adding one or two variables on design to an aggregate innovation index will probably not capture the variety which exists between industries, still less catch what happens within industries.

A set of five or six different indicators which aim to capture different aspects of industrial creativity must, in addition, not necessarily consist of totally exclusive indicators. Some of these indicators – like R&D intensity, design intensity and technological intensity – will include activities which can be measured in cost terms and related to sales, production or value added. We may here include data not only on activities performed within firms but also on acquisitions and sales between organisational entities. R&D intensity may thus be measured with the amount of R&D performed in the firm and the amount purchased by the firm from a consultant, i.e. a KIBS firm. Sales of R&D work should be treated similarly. Design intensity may, likewise, be defined/constructed not only based on design activities performed within the firm but also on the design services bought from, or sold to, external actors. One implication of this is that firms may be asked to classify parts of their knowledge related transactions and make them available for future innovation surveys or other means of data acquisition. Firms which buy/acquire design solutions and R&D may indicate an absorptive capacity to transform knowledge into profitable activities as well as demonstrating networking in knowledge formation.

Indicators like these may, under certain circumstances, show problems of aggregation as some data may appear in several firms and industries (two firms may, for example, acquire the same technology from a third firm). Those problems have to be considered but are probably not severe. Such a system of indicators may potentially capture the innovativeness of networks and inter-firm relations where some nodes may be more innovative than others. This is a problem has long been identified by innovation researchers.

As is discussed in Sections III 2. to 4. below, in the course of their work PILOT researchers also identified another serious deficiency in the current system of indicators. The factors that underlie the innovativeness of many of the firms that were studied cannot possibly be explored with common innovation indicators because these firms undertook virtually no R&D as conventionally defined. As a result, it will be necessary to undertake more deeply grounded examinations of the innovative activities of LMT firms in order to determine what they are, in fact, doing when they generate new products and processes, and then to see if the results can be systematised to increase the general level of understanding of LMT innovation. At the moment, it seems clear that their innovation rests on two main sets of practices. Firstly, these firms solve technological problems jointly with other firms that have better R&D capabilities, but the inspiration, a good deal of guidance, and much of the testing are intellectual activities performed by the LMT partners. Secondly, LMT firms frequently engage in important and complex adaptive activities in order to make technological innovations developed for other purposes suitable for their own ends. These are clearly important actions in promoting the diffusion of high-tech innovations throughout the economy, but at present little they remain *terra incognita*.

Although PILOT researchers were not able to do this topic full justice within the bounds of the project, it is a very promising area for future research, and one that should be of benefit to both managers and policy makers.

### 1.2. Conclusions and Policy Implications

The present industrial classification systems are not well equipped to catch the fundamental phenomena of the modern knowledge based economy. Service sectors are especially poorly developed and crudely identified in the present classification scheme which is problematic in an epoch when much creative activity is outsourced to knowledge intensive service firms or – the mirror image of this process – when manufacturing firms outsource their manufacturing activities, thus transforming themselves into service firms. The broadening of the innovation/creativity concept as suggested in PILOT will contribute to making innovation analyses more relevant for more firms and industries than hitherto.

1. On an *industry level*, the project's taxonomic work has contributed to a more nuanced approach to innovation and technological change by:

- placing R&D (and science) as one mode of knowledge formation among others – the *relativisation* result;
- introducing a family of indicators describing the variety of knowledge formation – the *variety* result; and
- opening for consideration high quality performance/skills and creativity in addition to the traditional innovation concept – the *broadening* result.

2. On a *policy level*, the work has contributed tools for formulation of a more nuanced view on knowledge formation policies. It may be argued that PILOT contributes by giving prominence to the contribution of non-R&D classified skills and creativity in all sectors. It also contributes towards the formation of policies for knowledge-based societies built on understanding the processes taking place in the non-manufacturing sectors of the economy which traditionally record much less R&D.

3. On the level of *data acquisition*, PILOT has shown – in theory as well as in an empirical illustration based on data from Norway (cf. Laestadius et al. 2006) – that is it possible not only to develop the present methods of data collection but also develop a new family of indicators which show the variety within industries.

In short, there is a great deal of creativity and knowledge formation taking place in significant segments of the so called the low-tech sectors.

## 2. Quantitative Analysis in the PILOT Project

During the course of the PILOT project, five main themes were addressed with quantitative methods:

1) Identification and analysis of growth patterns in modern developed economies.

2) Evaluation and improvement of existing indicators to measure innovation and growth in low-tech industries.

3) Europe-wide analysis of innovation in low-tech sectors.

4) Elaboration of a viable growth theory.

5) Survey of formal qualification structures in low-tech industries.

### 2.1. Methods and Databases Used

The methodologies used range from basic descriptive statistics, to different types of correlation analysis and regression analysis, and finally to the analysis of inter-industry or inter-sectoral trade flows applying more advanced modeling techniques.

The findings and results as presented below are on three levels: (1) the whole of Europe; (2) individual European countries; and (3) different groups of European countries. We have exploited the data to enable cross-country comparisons and the calculation of the European situation considering as many of the European countries as possible.

#### 2.1.1. Aggregated data sources

We have used four basic sources of international industrial and economic data for studies of industrial dynamics and economic growth at macro level:

- Datasets developed by the OECD, in particularly STAN, ANBERD, and the National Accounts datasets.

- Datasets as supplied through the OECD, based on data production or manual systems provided by a range of international agencies, such as the ILO-based Labour Force Surveys and the UN ITCS International Trade by Commodity Statistics.

- Datasets supplied by various UN agencies and related organisations, such as the UNIDO INSTAT databases and data provided by the IMF.

- Economic and social data and statistics on Europe, primarily on the EU and EEA Member States. The statistical agency EUROSTAT is responsible for collecting and analysing these statistics on the basis of deliveries from Member States' statistical agencies, and for generating related pan-European statistics.

- In addition various agencies and directorates general of the Commission provide relevant and issue-based aggregate statistics and analyses. An illustration is the series *Panorama of European Business* developed under the auspices of Enterprise DG, in collaboration with EUROSTAT and the authorities of the Member States.

Generally speaking the various OECD databases provide a broad set of relevant indicators of economic development in manufacturing industries, but at a fairly aggregated level (2 and 3 digits in the NACE classification). In the following sections, we present the main structure of these databases and their content.

**OECD database for Industrial Analysis (STAN)**

The STAN database includes annual measures of output, labour input, investment and international trade. STAN has been used in studies of productivity growth, competitiveness and general structural change. Through the use of a standard industry list, comparisons can be made across countries. This list enables definitions of high-technology and low-technology sectors and is compatible with those used in related national databases.

STAN is based primarily on the Member Countries' annual National Accounts by activity tables and uses data from other sources, such as national industrial surveys, to estimate any missing details. Since *many of the data points are estimated*, STAN does not represent official member country submissions. The newer versions of STAN (2003 and later) are based on the International Standard Industrial Classification Rev.3 (*compatible with NACE Rev.1*) and have been expanded to cover all activities including services and a range of variables. STAN has been merged with the OECD's International Sectoral Database (ISDB) which is no longer updated. Using STAN it is possible, among other things, to identify industries of rapid growth and of high productivity within individual OECD-countries.

**Analytical Business Enterprise Research and Development database (ANBERD)**

This database is designed to provide internationally comparable time-series on industrial R&D expenditures. The ANBERD database is developed to provide a consistent data set that overcomes the problems of international comparability and breaks in the time series of the official business enterprise R&D provided to the OECD by its Member countries *through the OECD's R&D survey*. It comprises data for nineteen of the largest R&D performing countries. These are: Australia, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, Spain, Sweden, the United Kingdom and the United States (plus the zone total for the European Union).

**The OECD Labour Market Statistics Database (LMS)**

LMS brings together data that are regularly collected to support the OECD's editions of the Employment Outlook and more generally to support work related to labour markets and social policy areas. The topics covered are labour force statistics, earnings dispersion, statutory minimum wages, wage rates, taxation of wages, trade union memberships, etc. This database may be useful in an investigation of the importance of labour market differences for low-tech industry performance across countries.

**ITCS International Trade by Commodity Statistics**

This database of yearly data covers international statistics on the foreign trade of OECD countries as well as China, Hong Kong and Chinese Taipei and provides exports and imports data on commodities and partner countries (up to 260 countries) in terms of value (expressed at current prices in thousand of US dollars) and quantity.

The OECD publishes data using two different classifications of commodities:

- SITC (Standard International Trade Classification): ITCS-SITC Rev.2 and SITC Rev.3

- HS (Harmonised Commodity Description and Coding System): ITCS HS 96.

The SITC/ITCS is a relevant data source in a study of trade patterns of low-tech products. However, it does not provide information about trade of low-tech or high-tech products from industry to industry.

HS is a more detailed classification with 6-digit subheadings. Since 1988, the OECD has received data according to HS or on a more disaggregated level. Data are then converted into SITC Rev.3 and Rev.2. From 1991, data may be obtained according to SITC Rev.2, SITC Rev.3. From 1996, data may be also obtained according to HS 96. However, it should be noted that, while it is easily feasible to convert data from a recent revision to an older one, the conversion from SITC Rev.2 to SITC Rev.3 is quite delicate, if not impossible. Consequently, to obtain a consistent time series, one should carefully choose which revision to use. Up to 1990 data are only available in SITC Rev.2, which are contained on the *Historical data CD-ROM* in SITC Rev.2.

**UNIDO's Industrial Statistics Database (INSTAT 3 and 4)**

INDSTAT-REV3 contains time series data on seven variables for the period covering 1990 onwards. The data are arranged at the 3- and 4-digit level of ISIC (Revision 3) pertaining to the manufacturing sector, which comprises 151 manufacturing categories.

Variable information is presented by country, year and ISIC category and includes the number of establishments, employment, wages and salaries, output, value added, gross fixed capital formation and the number of female employees. The database allows for data conversion from national currency into current U.S. dollars using the average period exchange rates as given in the IMF International Financial Statistics (IFS).

INDSTAT4 provides industry information based on the ISIC (Rev.2) classification at the four-digit level for the period 1981 and onwards. INDSTAT4 comprises 81 manufacturing industries. As in the case of INDSTAT-REV3, information is presented by country, year and industry, and each of the seven variables are covered.

Within the reference period, the coverage of years differs from country to country both in INDSTAT-REV3 and 4. INDSTAT data are compiled in collaboration with the OECD. Data for non-OECD countries are collected by UNIDO while those for OECD member countries are collected and provided to UNIDO by the OECD for inclusion in the database. Therefore, the UNIDO database is adequate for international comparisons and for development studies but it does not provide industrial data on the level of detail needed in PILOT.

There are of course many other additional data sources relevant to studies of industrial dynamics and economic growth. The financial data of the IMF and the World Bank are an obvious reference here, especially when the focus is on the relationship between financial stability and innovation. However, these databases were not directly relevant to PILOT.

### 2.1.2. Disaggregated data sources

In PILOT there is, however, the need for data at a much more disaggregated level. The most important disaggregated data sources are:

- The Community Innovation Survey (CIS-data) and
- EUROSTAT-Statistics for industry and services at the firm-level

**CIS-data**

The Community Innovation survey (CIS), launched in 1991 by Eurostat, aims at improving the empirical basis for innovation theory and policy at the European level through surveys of innovation activities at enterprise level in the Member States. The first Community Innovation Survey – CIS I – was launched in 1992. The second survey started in 1997 and was completed in 1999. The third survey was carried out in 2002 and the data were available for research purposes at the end of October 2003.

CIS surveys collect firm-level data on inputs to, and outputs from, the innovation process across a wide range of industries and across Member States. In contrast to OECD's ANBERD database, CIS-surveys provide internationally comparable data on non-R&D resources, devoted to innovation and on the output of the innovation processes. Data collection is done at regular intervals.

Based on previous CIS-surveys, we have strong reasons to believe that for many industries there is a significant variety between firms as regards their innovativeness. CIS data suggests roughly that we may assume that 80 percent of innovative products are sold by 10-20 percent of the firms within any industry.

We also assume – again on the basis of CIS innovation expenditure data – that there is variety as regards different types of knowledge formation between and within low-tech industries. Some firms are more innovation oriented than others, some are more focused on training and skills, and there is a considerable variety in the use of new capital goods.

Although this *heterogeneity* within and between industries across countries is very likely to be the prime determinant of observed differences of labour productivity in low-tech and medium-low-tech sectors between countries, it may illuminate what forces lie behind the stability of size of LMT industries across countries.

For example, it is possible to identify (through STAN) the five fastest growing NACE sectors in some European countries and then to look at the CIS-3 data for those sectors in order to find:

- the proportion of innovating firms for each sector;
- the average sales for new and changed products for each sector;
- the cumulative distribution of new and changed products;
- the structure of innovation costs for each sector (with proportions in the three categories of R&D, non-R&D, and capital expenditure).

**Statistics for industry and services**

Another related issue is the entry and exit of firm dynamics in low-tech and medium-low-tech industries. To what degree do experimentation and new entries take place in LMT industries across countries? What are the determinants of such dynamics and their impact on the innovation activities on LMT industries? For all these purposes there is need for registry data at the enterprise level. However, few countries produce such statistics.

The OECD's main industrial indicators provide figures for four industry groups based on an ISIC revision 2 classification of technological intensity (CTI) as defined in Hatzichronoglou (1997). These four groups of industries are: Low-technology industries – Medium-low-technology industries – Medium-high-technology industries – High-technology industries

Despite the fact that this classification may be useful for macroeconomic analysis of the relationship between technological change and economic growth, one has to be aware of the serious limitations and pitfalls of using it uncritically.

Firstly, the CTI taxonomy is constructed primarily in order to investigate the contribution of high-tech sectors to economic growth.

Secondly, the definition of technology intensity is based on R&D intensity (estimated on the basis of total R&D expenses, whether performed intra- or extra-morally) as the core criterion. In addition, technology intensity is in principle defined by including product-embodied technology flows. The indirect component of technology intensity includes a measure of pecuniary externalities, or market-based embodied R&D spillovers, as measured on the basis of intensities of trade flows by the input-output matrices integrated into the ESA/SNA National Accounts Systems. Though this is included in principle, use of the taxonomy is generally reduced to the basis of direct inputs of R&D. Including indirect technology flows in the equation of the taxonomy changes the absolute and relative variation in technology intensity of sectors – and hence their classification as one or the other of the four classes. R&D performed by or supplied on contract to business companies is an important dimension of innovation inputs in high-technology industries. The structure of innovation costs and past innovation performance of low-tech or medium-low-tech industries suggests that this is not the case for companies in these industries. Low-tech industries may often be highly innovative and have complex knowledge and competence bases for their activities, despite the fact that they invest only weakly in R&D. Hence the suggestion is that such companies have other means than R&D – as measured in the Frascati style national R&D surveys – to accomplish competence and knowledge generation and deployment and innovation.

Thirdly, the CTI is lacking sufficiently disaggregated data. The principal limitation associated with that is that many products manufactured by medium-low-tech or low-technology sectors may be high-tech and some of the products made by medium high-tech or high-tech industries may be medium- or even low-tech (Hatzichronoglou 1997: 8-9). In order to overcome this difficulty the OECD also developed a product classification approach, but this has not been taken into consideration in this report.

Fourthly, CTI is only consistently constructed for manufacturing industries (Category 3 in ISIC Rev.2, industry areas 15-37 in NACE Rev.1 or its equivalent ISIC Rev.3). It is unknown to what extent the OECD's choices are based on a "manufacturing bias" but a core problem for applying the taxonomy to service industries is the lack of a representative coverage across countries of service industries in the national R&D surveys.

### 2.2. Results

The five themes outlined at the beginning of this section overlap significantly. In this report we present the research within the themes by considering the overall common denominator of the project, namely the investigation of industrial structure, growth and innovation in relation to low-tech and medium-low-tech industries. This has shown the need for documentation of industrial structure, growth and innovation by means of descriptive statistics. But, being more ambitious, it has also implied a need for research whose principle reference is to obtain insights into *the connection* between industrial structure, growth and innovation.

The rationale of the PILOT project is based on an unease about the prevailing domination of the high-tech argument in innovation and growth, that is, about the conventional wisdom that high-tech industries dominate in advanced economies, by means of their innovation, and by means of their contribution to growth and structural change. The linear model of innovation – the belief that science based knowledge is the input and innovation is the output – represents the historical and contemporary culprit when the high-tech argument is to be explained. One main objective of the project was to challenge this. We contend that growing knowledge intensity of economic and social development in Europe (and elsewhere) is not only based on industries with science-based, so-called frontline technological knowledge. It is also highly dependent on low- and medium-low-tech industries. We show that they also are users and producers of sophisticated knowledge.

In sum the results of our research represent a leap forward in the rethinking of innovation research and innovation and economic policy making, in particular in terms of understanding industrial structure and in terms of understanding innovation and growth in the economy. As mentioned, the results are challenging the conventional wisdom, in particular in relation to R&D and innovation policy. They consequently have radical policy implications. The findings re-establish the significance and importance of low- and medium-low-tech industries in innovation and in economic development and growth. We summarise and analyse the findings within the overall headings of *Industrial structure and growth* and *Innovation*.

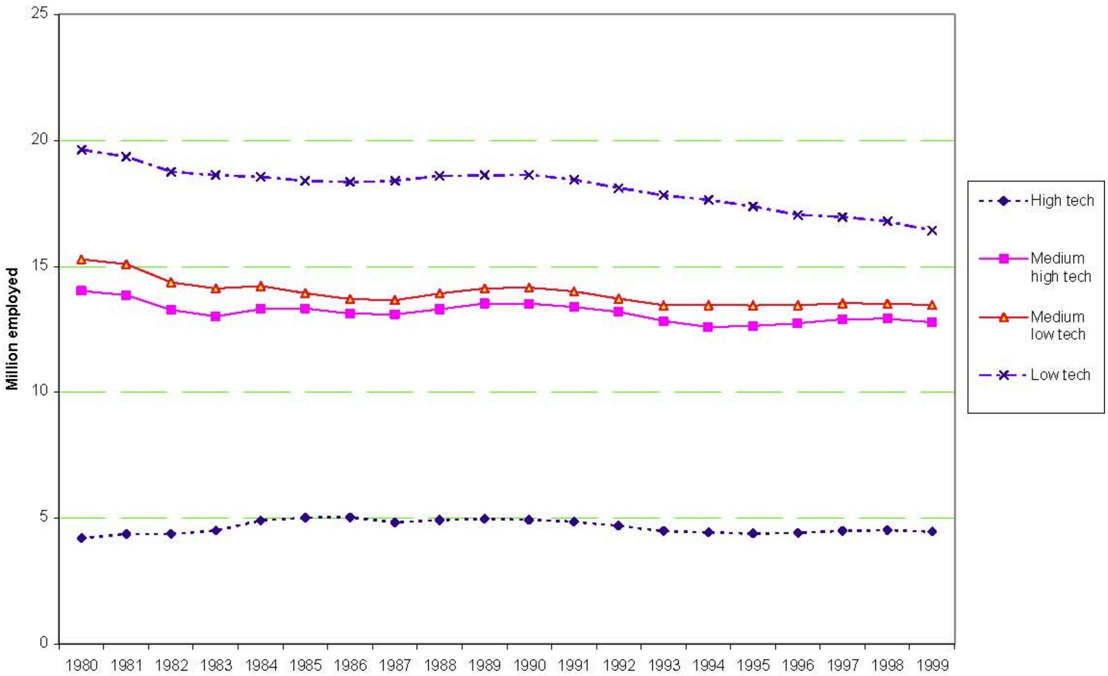
### 2.2.1. Industrial structure and growth

Early phases of quantitative work in the PILOT project were dominated by the collection and organisation of basic statistics and the investigation of industrial structures. The work was communicated as project-internal deliverable during the first project year (Kaloudis 2003). The statistical analysis outlines the major patterns of recent economic growth in Europe and elucidates how various industries and sectors contribute to this process. In classifying national and European level specialisation patterns, we use the criteria of various OECD taxonomies to identify high-, medium- and low-tech industries, as well as distinguishing resource-, scale- and knowledge-intensive industries to characterise major patterns of structural change at the national level.

The work includes an overview of and analysis based on internationally comparable data comparing growth performance between Member States and within the Triad comprising the European Economic Area, US and Japan. This analysis was based on OECD data – mainly on the OECD STAN, ANBERD and National Accounts databases – and on EUROSTAT data – primarily data from the New Cronos database. The paper takes OECD's groups of manufacturing industries according to R&D-intensity as a framework and analyses trends in six types of variables: 1. Value added, 2. Employment, 3. Labour productivity, 4. R&D expenditures/intensity, 5. Investment intensity and 6. Export specialisation.

Based on this work, aspects of the economic development in Europe during the two decades since 1980 were characterised. Indicators have been constructed both on the level of individual countries, with an emphasis on the PILOT partner countries, and where available at the European level to facilitate a comparison within the Triad between Europe, US and Japan.

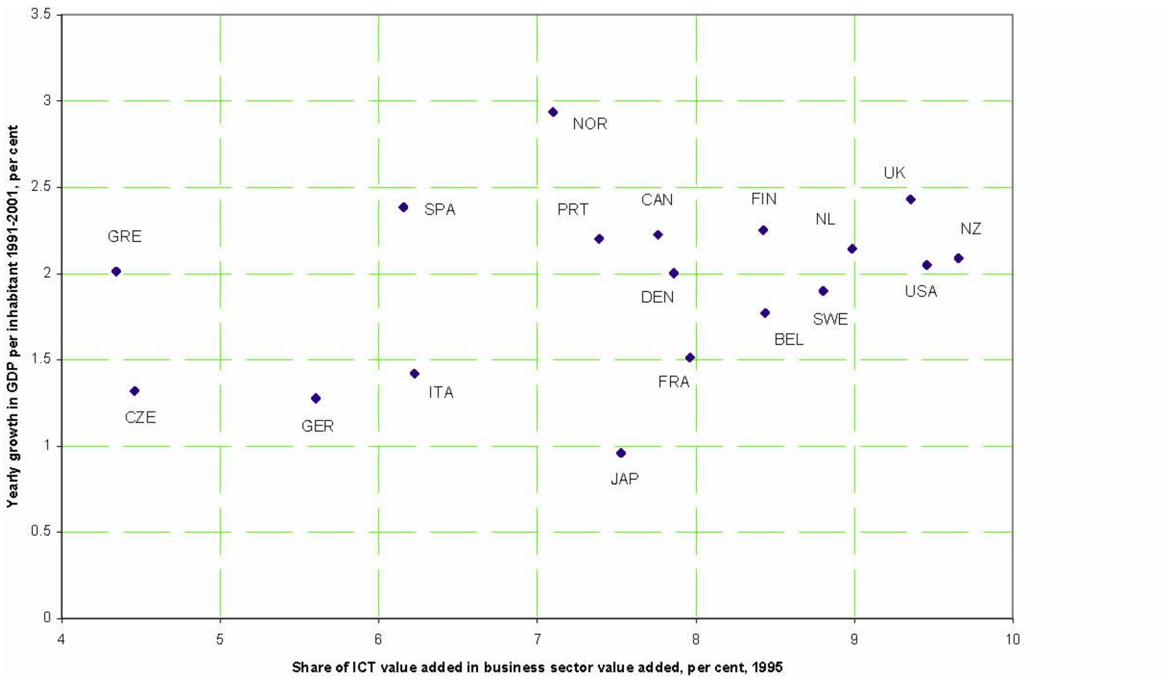
**Figure 1.** Number of persons engaged (in million employees). 1980-1998; 11 OECD countries combined.




The main message from the descriptive statistics is that low-tech and medium-low-tech industries (LMT) are the main actors when the theme is growth patterns in European economies. As Sandven et al. (2004) show in some detail, the significance of low tech industries in overall growth is clearly underestimated, despite some reduction in their relative importance. Figure 1 indicates the significance and persistence of LMT industries in the OECD countries over the last two decades of the last century.

As the high-tech argument represents the belief that the high-tech industries dominate in a trend of growth and structural change, we went further into an analysis of the relation between industrial structure and growth. In our quantitative investigation we found no positive and significant correlation between shares of high-tech in total output of an economy and levels of growth rates. The structural diversity that characterises European countries is not reduced over time, in the direction of larger high-tech sectors in total economy, as growth proceeds. Countries that have experienced a rapid diffusion of information and communication technologies (ICT), or which have been involved in significant production of ICT, are not ahead of other countries. There is no particular link between ICT and growth. We found no serious signs of the expected falling employment in low-tech sectors, which is claimed to be a result of high-tech growth and of trade effects, i.e. as low-tech and medium-low-tech industries move to low-wage environments. This has not happened. The differences in growth rates of production across the four tech classes in manufacturing seem to be closely mirrored by differences in the growth of domestic demand. Figure 2 indicates the argument.

**Figure 2.** Shares of ICT industries' value added in total business sector (x-axis) Annual compound growth rate in GDP per capita 1991-2001 (y-axis)




### 2.2.2. Innovation

Given the fact that innovation is intrinsically a part of our argument, our findings have profound policy implications when it comes to innovation as well. Generally the findings conclude that innovation is largely distributed across all industries (Hirsch-Kreinsen et al. 2005), as low-tech and medium-low-tech industries innovate intensively. Yet, when product and process innovation is seen together, LMT industries do not innovate as intensively as the high-tech industries. This is however where our findings start to get interesting. Our European level innovation analysis, which includes a group of deliverables that are based on Community Innovation Survey data, document a distinct pattern of how medium-low-tech and low-tech industries innovate. On the one hand, our work on innovation took as point of departure existing work on the European machinery industries (machinery and electrical machinery). Within the PILOT project, we have made a comparison of the machinery industries with other industries, and we have also studied a specific aspect of innovation namely patterns of inter-industry linkages. The work is complementary and reveals a systematic dichotomous pattern of innovation in European industry.

On the one side there are the machinery industries, which because of their R&D intensity are to be classified together with the medium-high-tech and high-tech industries. How does innovation occur in these industries? We find one very clear dimension in the data, manifesting itself in several of the variables. It distinguishes enterprises by what we might call internal innovative capacity, that is, the extent to which they generate innovations based on their internal resources and internal innovation expenditures, as opposed to external sources, and the buying in of processes.

This dimension manifests itself in an inter-correlation of several different variables. We start by considering the enterprise level. One central variable here is the distinction among innovative enterprises, between those with product innovations (whether only product innovations or also process innovations) and those with only process innovations. Based on the available date we find that the former group of enterprises, with both product and process innovations, is by and large the high-tech industries including machinery industries. The latter group, with only process innovations, comprises mainly low-tech and medium-low-tech industries.

Another distinction relates to who developed the innovations of the enterprises. That is, we can ask whether different types of innovations are developed mainly inside the enterprise itself, mainly in collaboration with other enterprises or institutes, or mainly by other enterprises or institutes.

Among enterprises with mainly process innovations, there seems to be a substantially higher proportion of innovations that are based on contributions developed by others than is the case among enterprises with both product and process innovations. Enterprises with both product and process innovation substantially developed such innovations mainly within the enterprise itself. That is to say, the innovativeness of LMT companies seems to be to a large degree based on the capabilities to take up knowledge generated elsewhere and transform it according to their needs and possibilities.

The Community Innovation Survey (CIS) data provide us with an interesting picture of innovation in low-tech and medium-low-tech industries. Even though it may be argued that the framework and design of the Community Innovation Survey is somewhat biased towards the high-tech argument in the sense that the focus on specific types of product innovation ("radical") is strong, our findings correspond well with the findings from the PILOT project's qualitative empirical investigation of innovation in companies across Europe. Low-tech and medium-low-tech industries tend to be process innovators and they often innovate by means of investments in machinery for example. The other types of innovations which the case studies reveal that low-tech firms are into, are not revealed by CIS data.

The other deliverables with analytical value for the topic of innovation complements the findings from the mentioned studies and the case studies. The topic is inter-industry linkages. It includes several papers. Robertson et al. (2003) treat the theme thoroughly both conceptually and empirically. The authors draw upon some of the best known and influential parts of growth theory by Dahmen, Rostow and Schumpeter in an investigation of the relationship between rapidly growing sectors and sectors that are already established and mature. One of their main messages is that patterns of long-run structural change in developed economies may depend heavily on maintaining the short- and medium-run competitiveness of established industries because these often provide the major sources of demand required to offset the R&D costs associated with innovation.

To fill this role effectively, firms in established industries need adequate levels of "innovation enabling capabilities " (cf. below section III 3.), i.e. access to the intellectual, physical, and financial resources that will allow them to adopt innovations quickly. Hauknes and Knell (2005) take the arguments of inter-industry linkages further. Their results, based on CIS data, indicate that low-tech and medium-low-tech industries to a greater extent than high-tech industries collaborate with external actors in their innovation. The work does not capture innovation but flows of R&D as a proxy of innovation collaboration. The main message of the paper is that high-tech industries and low-tech and medium-low-tech industries depend critically on each other. The structure of the bi-directional dependencies between high and low technology industries is significant.

### 2.3. Conclusions and Policy Implications

This research is a fundamental criticism of the existing knowledge base that policy makers generally employ. It represents a foundation for a radically adjusted research and innovation policy as policy tools for industrial development. The research in the PILOT project is above all innovative when used as knowledge base for policy learning. This is a hard nut to crack. It is within the policy domain that the high-tech argument shows particular persistency.

In sum, in terms of industrial structure, change and growth, there is substantial variation across the countries when it comes to the shares of output and employment accounted for by high-tech industries – there are quite different sectoral mixes that persist over time. In this context we found no evidence of any simple relationship between technological intensity of the industrial structure and economic growth at the total economy level. There is no simple relationship to the effect that the high-tech economies are also the high growth economies. This suggests that different economies can follow different routes to economic growth. Countries play different roles in an economic system which is differentiated at the international level, and in which there is a division of labour among the highly developed economies.

Our analysis suggests that while new sectors emerge within the economy, and some sectors disappear, this does not account for the processes of growth which actually occur across the OECD. The growth trajectories of the advanced economies seem to rest as much on such sectors as engineering, food, wood products, and vehicles and so on, as they do on such sectors as ICT or biotech. Medium-low and low-tech industries have persisted over the past decades despite the claims that we are undergoing a kind of structural revolution. Moreover, we document that they are unlikely to disappear in the future. Why is this? Our argument is that these industries are far more dynamic and innovative than usually believed.

Our findings are that the persistence of low-tech and medium-low-tech industries derives from the fact that innovation in advanced economies has two broad but separate dimensions. On the one hand there are science-based or at least R&D-based innovations that create new industries or activities by opening up technological and commercial opportunities. Aerospace, ICT, and pharmaceuticals fall into this category. On the other hand, there are innovation processes that technologically upgrade existing industries and activities. Such changes are often ignored because of asymmetric attention by analysts (and policy makers) to arbitrarily selected new technologies. However technological upgrading in medium-low- and low-tech industries is pervasive and can be both incremental and radical. Incremental change upgrades and endogenously changes industries over the long run. Radical innovations in medium-low-tech and low-tech activities, such as the container revolution, or new forms of adhesives, or new materials in textiles and clothing, can have important growth impacts.

We argue that the persistence of LMT industries requires much closer attention to both of these forms of innovation. We hypothesise that these industries survive in the OECD economies because they exemplify such omnipresent forms of innovation and knowledge creation. This implies that growth is primarily based *not* on the creation of new sectors but on the internal transformation of sectors which already exist. Overemphasising the role of high-tech activities ignores this major dimension of change in advanced economies.

There are those who would agree with the broad views expressed here, but argue that innovation and growth in medium-low-tech and low tech industries is nevertheless shaped by high-tech sectors, because they supply intermediate and capital inputs that embody the knowledge intensity of other sectors (the most systematic approach of this kind is Pol et al. 2002). Without entering these arguments in detail here, we would raise objections resting on the fact that only one high-tech sector really supplies inputs to a wide range of other sectors, and that is ICT. There is no question that the incorporation of ICT components into medium-low-tech or low-tech products and processes is a key element of innovation within those sectors at the present time. However this is only one element of innovation in such sectors. More significantly, there is a causality issue here as well: LMT sectors may not be passive recipients of ICT, but via their complex demands for inputs may actually be the shaping force behind the development of ICT as a technology and industry. If this is the case then LMT industries continue to play a key role in the technological evolution of the advanced economies.

The policy implications of our findings are as radical as they are simple. There is need for acknowledging the importance and significance of low-tech and medium-low-tech industries. This can be done by moving them upwards on the priority list and the agenda of policy makers in their efforts of developing innovation policy and economic growth. Moreover, the findings on innovation, innovation collaboration (cf. section III 4. below) and inter-industry linkages indicate strong interdependencies in the economy.

One may actually argue that if there is any issue that has been emphasised in the policy domain over the last years, it is the issue addressing network aspects and collaboration in research and innovation. From the perspective of the PILOT project and its findings, the high-tech argument has been persistent also in these types of policy instruments.

The problem is that the bulk of financial means is still allocated to research and innovation projects in which the high-tech knowledge component (and thereby high-tech industries and high-tech firms) is a mandatory part. Therefore, the simplest policy implication is also the most important one here. There is need for customising innovation policy that is adjusted to low-tech and medium-low-tech industries and companies.

Further studies may want to go beyond the OECD-based framework of high-tech and low-tech industries. A conclusion from the PILOT project is that the classification of industries according to aggregate R&D-effort as share of value added is not always enlightening. The main reason is the acknowledgement that knowledge formation and innovation occur in so many settings beyond or outside what is labeled R&D. What is interesting is to go into details on how specific sectors and ultimately how specific firms interact with each other, making up the dynamics of industrial life that we argue is the empirical backbone of structural change (persistence) and growth in the European economy. This approach to the problem may turn out to be one of the bigger challenges for innovation studies in the future, given the strong trend of researching sectoral systems of innovation, in particular in the EU Framework Programmes. And this is of course not limited to quantitative empirical investigation.

**3. Company Case Studies**

The basic hypothesis of the PILOT project has been that low-tech and medium-low-tech industries are highly relevant for growth and employment in European economies. It is, of course, practically impossible to verify this hypothesis with case studies. Instead, the case study research within PILOT served to complement the results of the quantitative work described above with illustrations of constellations of problems and capabilities on the micro- and meso-level of individual companies. And it thus helped to specify more precisely questions relevant for both future research and policy. The respective empirical investigations focused on innovation strategies and characteristics, the related knowledge bases, organisational strategies in general, management practices and human resource policies of the firms.

Processes such as innovation or skill formation can hardly be operationalised in such a way, that a proper analysis with sample or population surveys is possible. Thus, a comparative qualitative procedure seemed to be the appropriate methodology to map the complex dynamics of competencies and the utilisation of knowledge in LMT industries. In contrast to solely quantitative methodologies, this facilitated a greater flexibility, in-depth-focus and particularly the possibility to gain "deep data" and "thick description". Needless to say, this qualitative approach is itself connected with some serious analytical and theoretical weaknesses – mainly in terms of the generalisability and the transferability of the research results. However, considering the heterogeneity of our field of research and the fact that it was (and still is) relatively unexplored, a qualitative research design seemed indeed appropriate. There were two crucial issues that had to be taken into account in making this choice.

First, there was the question of the clarity of the concerns of the study. In a field where much research has already been done and the important hypotheses are already clear, all that remains is the empirical evidence to prove or disprove the hypotheses. This is usually best done by converting the hypotheses into clearly formulated questions in a survey. If the hypotheses are clear, if the survey questions clearly relate to the hypotheses, and if the sample surveyed is large and representative enough, then the results can be argued to contribute to the empirical evidence supporting or opposing the theoretical hypotheses. On the other hand, where – as in PILOT – the concerns of the study are relatively new, where it is unclear as to what precisely the key questions are, or where the study is as much exploratory as definitive, then closely examining individual cases can frequently provide better results than quantitative surveys. If the theoretical development is relatively young, the in-depth examination provided by case studies has advantages because it facilitates observation of a larger number of variables, rather than the larger number of records provided by surveys. As Yin (1993) argues, the case study approach is particularly appropriate where there are multiple sources of evidence but it is difficult to distinguish the issue to be studied from the context within which it is located. The patterns of relationships among the variables, drawn from the multiple sources, can then be used to develop the hypotheses already extant in more developed research areas. Thus case study research is associated with more inductive epistemologies.

A second issue relates to scale and selectivity in the context of a multi-country study like that of PILOT. With the case study approach the cases can be deliberately chosen so as to maximise the opportunities for learning through cross-case comparison (Stake 1994: 243). Yin (1994) suggests that the advantage of multiple case study analysis (over single case) is the increased robustness of the results, which in turn strengthens the credibility of the research and enhances the generalisability of the theoretical propositions developed (cf. Hillary 2002). "Cases, like experiments, are generalisable to theoretical propositions and not to populations or universes" (Yin 1994: 10). Cases should be selected so as to be either predictably similar or predictably different. Yin (1993) suggests selecting a mix, beginning with exemplary cases, which provide strong examples of the issue being researched. Maxwell (1996) offers a number of choices for the sample composition: (a) representative or typical cases; (b) the full range of possible cases; (c) critical cases; (d) controlled comparison cases. On the basis of these recommendations case study firms were chosen that are both similar and different, that are in the same industries and different ones, and that in various respects would be expected to illustrate the issues raised in the idea that high-tech and low-tech are inappropriate categories.

Regarding the actual realisation of the empirical field work, one has to bear in mind the international character of PILOT, as a project based on the collaboration of different scientific disciplines and institutions from nine diverse European countries. This had some crucial methodological implications. Within the context of a qualitative research design, a certain degree of standardisation in the concrete field work had to be elaborated to ensure a reasonable degree of comparability of the individual research results made by different research groups – each with an own distinct national background. To cope with this productively was a major and indeed quite laborious task in both the conceptualisation and coordination of the case study work.

### 3.1. Research Design and Methods

The field of LMT industries is extremely wide and heterogeneous. Hence, one of the first methodological tasks was to come to a reasonable understanding on the sectors on which the empirical research should focus. The selection was based on results of a prior statistical evaluation (STEP 2003). Each project partner conducted half of his case studies in a common sector, namely "Manufacture of fabricated metal products, except machinery and equipment" (NACE DJ.28). The case studies were determined nationally on the basis of a range of pre-selected sectors:

- food, beverages and tobacco (NACE Subsection DA); or
- textiles, apparel and leather (NACE Subsections DB and DC); or
- wood products (NACE subsection DD) and furniture (NACE DN.36); or
- paper, paper products and printing (NACE subsection DE).

The main criterion for the final selection (cf. Table 1) was a sector's importance in the state or region in terms of growth and/or employment.

**Table 1.** PILOT case studies (cf. VI 1. Annex 1 for full name of the partners)

| Partner | Sector | Products |
|---|---|---|
| AIER | Textiles, apparel & leather | Industrial textiles |
| | Fabricated metal products | Pull-out & hinge systems for furniture |
| | Fabricated metal products | Rails |
| | Fabricated metal products | Railway points |
| CAULU. SSI.PEM | Food, beverages & tobacco | Frozen fruit and vegetable |
| | Food, beverages & tobacco | Pasta |
| | Fabricated metal products | Parts for vehicles |
| | Fabricated metal products | Cooling systems |
| DCU.BS | Wood products & furniture | Furniture |
| | Wood products & furniture | Furniture |
| | Fabricated metal products | Precision components |
| | Fabricated metal products | Flow-pumping systems |
| FILOV | Fabricated metal products | Car-wheels (aluminium) |
| | Fabricated metal products | Sintered mechanical components |
| | Textiles, apparel & leather | Medium and high-end clothing (design) |
| | Textiles, apparel & leather | Clothing (production) |
| ISFE | Paper & printing | Very fine paper |
| | Paper & printing | Standard mass paper |
| | Fabricated metal products | Industrial lifting equipment |
| | Fabricated metal products | Valves |
| RIT.IEM | Fabricated metal products | Hand tools |
| | Fabricated metal products | Bathroom fittings |
| | Wood products & furniture | 'High-end' office furniture |
| | Paper & printing | Standard paper |

| | | |
|---|---|---|
| STEP | Fabricated metal products | Sockets, plugs and switches |
| | Fabricated metal products | Hydraulic and mechanical equipment |
| | Food, beverages & tobacco | Fish products |
| UDTM. ESS.TS | Wood products & furniture | Swivel chairs |
| | Fabricated metal products | Metal tubes |
| | Metal production | Steel profiles |
| | Fabricated metal products | Electrical heating elements |
| UJAG.MAN | Paper & printing | Printing house |
| | Food, beverages & tobacco | Meet products |
| | Fabricated metal products | Mounts & links |
| | Fabricated metal products | Steel platform gratings, stair treads |
| UOVE.FUN | Fabricated metal products | Railway parts |
| | Fabricated metal products | Aluminium ingots |
| | Food, beverages & tobacco | Dairy products |
| | Food, beverages & tobacco | Dairy products |
| VTT.GTS | Fabricated metal products | Ship propellers |
| | Fabricated metal products | Metal parts for the building industry |
| | Paper & printing | Packaging material |

The selection of companies could obviously not be a representative sample. To qualify as a PILOT case a company had to be *innovative* (regarding products and/or processes), economically *successful* and of a critical *minimum size* (about forty-five employees or more). The final sample comprised forty-three firms from five different sector-groups (cf. Table 2).

**Table 2.** Size (personnel) and sectors of the case study firms

| Personnel | Paper & Pulp | Textile | Food | Wood & Furniture | Metal | Σ |
|---|---|---|---|---|---|---|
| < 51 | | 1 | 1 | 1 | 5 | 8 |
| 51–100 | 3 | 1 | 2 | 2 | 6 | 14 |
| 101–250 | 1 | | 1 | | 6 | 8 |
| 251–500 | | 1 | 1 | 1 | 5 | 8 |
| > 500 | 1 | | 1 | | 3 | 5 |
| **Σ** | 5 | 3 | 6 | 4 | 25 | 43 |

For the enquiry, a standardised questionnaire was used to collect basic data on the respective company, its production process and its relations to suppliers, clients and, if relevant, partners. This research instrument was complemented by about half a dozen semi-structured intensive interviews for each case study with company representatives on different levels and with different functions (based on a master guideline common for all national project teams; cf. Box 1), by site inspections and by an analysis of publicly available documents of the firms (catalogues, product specifications, internet presence, self-portrayals etc.).

**Box 1.** Basic themes itemised in the interview guideline

- Knowledge base
- Ways to generate and use knowledge
- Patterns of innovation
- Interchange with high-tech partners
- Other cooperation regarding innovation
- Influence of market conditions on innovative behaviour
- Recent organisational change
- Workforce policy/industrial relations
- Relevance of policies

### 3.2. Results

### 3.2.1. Work organisation and skills

There is definitely no LMT-specific pattern of work organisation and qualification levels. This heterogeneous segment of the economy is characterised by a variety of different types of work organisation. Its concrete form is determined by an interplay of many different factors – such as product complexity, types of machinery and automation in use, personnel policy, the market situation, quality requirements, customer demands. In some cases different forms of work organisation are applied within one company. Thus, a simplistic understanding that LMT firms are, as it were, by definition dominated by unskilled labour, a very high degree of division of labour and strict hierarchies is not supported by our data.

Nevertheless, there are indeed some examples of a Taylorist regime in the sample (rigid division of labour; very specialised work-force; sophisticated hierarchies; strict separation of conception, planning and control). But there are also more participative forms of work organisation with semiautonomous teams, job-enlargement, a low level of division of labour, flat hierarchies, moderate differentiation of qualifications within the manufacturing staff and a rather high overall qualification level. This latter type could primarily be observed when the production processes were complex with sophisticated machinery and a high degree of automation. In a few cases there have also been moves towards more autonomous forms of work organisation in order to enhance flexibility and shorten reaction times. And there are examples somewhere between these two extremes. Here one finds a rather strict division of labour between pre-production planning departments and manufacturing. However, within the limits of this basic model scheduling functions are to a greater or lesser extent shifted towards shop-floor personnel although most of them usually remain with group leaders, foremen or master craftsmen.

In our sample the case companies in the food sector come closest to the traditional Taylorist and hierarchic type of work organisation, while the investigated companies from the paper industry are characterised by a high level of dependence on a skilled workforce[5] and relatively advanced types of work organisation – often due to the use of sophisticated machinery and a de-coupling of automated process routines and human

[5] The term "skilled staff" is used here for personnel that has completed an apprenticeship of two or more years with a certificate. Semi-skilled workers do not have such a certificate but have taken part in courses and training on-the-job and gained (mostly) company specific competencies and experience. Unskilled workers possess no formal qualification; for their work, basic school education and a short introduction to the job are sufficient.

labour. Between these two poles we find the companies from the wood and furniture industry, the textile industry and the metal working industry (though there are examples of highly innovative modes of work organisation in the latter).

It is not possible to identify a clear trend for the near future as the companies seem to follow one of two contrary strategies: The first entails a (further) deskilling of the workforce in the immediate production process together with a concentration of competence at the white collar level (including engineers). The second strategy is directed at a general improvement of skills and qualifications without obvious downgrading of the skills of some segments of the workforce. Nevertheless, the bulk of the firms in the sample tend to concentrate strategic knowledge and competencies in a relatively small group of managers and technical staff while the production workers are more or less skilled executors. However, there is a growing number of firms introducing new modes of communication and organisational routines such as cross functional work groups, problem solving groups, continuous improvement schemes and the like to exploit the staffs' knowledge and abilities more comprehensively.

### 3.2.2. Technology and the role of automation

The investigated companies are characterised by core competencies in, in part, highly sophisticated process technologies and (though to a variable extent) logistics. "Low-tech company" as a classification is thus not synonymous with low-tech processes; watching the equipment employed and the production processes one does not necessarily mean that all this characterises a company which is low-tech according to the OECD definition (Hatzichronoglou 1997). Complex (semi-) automated production facilities are frequently deployed. The main strengths securing the competitiveness of such companies are often the capabilities to accumulate and permanently renew knowledge and know-how necessary to continuously improve design, production and commercialisation of their products.

The concrete shapes of the production process regarding the use of advanced machine equipment in the investigated companies are, again, manifold. We find companies that deploy – and in few cases even develop – highly sophisticated machinery and process technologies, as in the examples from the metal working and the paper industries,) and other companies which still draw to a great extent on traditional manual labour (as in cases in our sample that belong to the food- or the wood-processing industries). Though the latter approach is often a result of limited financial means, it can also be an intended consequence of a cost cutting strategy. Not surprisingly, line production and highly automated processes are predominantly applied in the manufacture of standardised mass products with few variants, such as mass paper or metal bars.

In some of the cases production processes are segmented. Routine phases are followed by critical segments requiring a relatively high skill level and multiple forms of knowledge and these again by unproblematic segments. Consequently, the process segments differ remarkably in both the implemented technology and equipment and the type of work organisation: phases of traditional "factory work" are followed by highly automated "clean" processes while the subsequent steps may be dominated by manual work again. It is very difficult to say in these cases whether a "modern" overall process is being interrupted by "traditional" episodes or the other way round.

### 3.2.3. Personnel policy and training

Skill levels are also heterogeneous. There are companies employing mainly cheap, unskilled labour while in other cases qualified workers' knowledge and competence was identified as being crucial for the company's success. Thus it is wrong to claim a general decline in relevance of blue collar workers' knowledge for the efficiency of production in LMT companies. However, this is not a technical matter only but also one of subjectivity and tradition. Some of the companies in the sample prefer to hire qualified personnel not so much because of their respective nominal qualifications, but because of their professional attitude towards work. A skilled workforce is considered to be more cooperative, reliable and loyal and thus less likely to cause disciplinary problems or conflict.

All in all, there is a close relationship in each of the investigated firms between technological innovation, organisational restructuring and training measures. But this does not end up in an LMT-specific pattern but, again, in heterogeneity. In a stylised way, one may identify two extremes of personnel policies (in practice the concrete forms are usually complementary and phase specific, and they are partially differentiated between different workforce categories). The first may be termed "advanced" personnel policies – participation, holistic use of labour, support of long-tern labour relations etc. – including strategically planned, simultaneous modification of work organisation and process technology. Alternatively, a short-term hire-and-fire policy, recruitment on the external labour market and as for technological and organisational change unsystematic muddling through (cf. Schmierl and Köhler 2006 for details).

Most of the firms in the sample apply a personnel policy that relies heavily on the use of internal training, usually provided on a more or less ad-hoc basis during daily work time and at the workplace. In most cases there is a large amount of variety and difference in intensity in the further vocational training that is provided. A high level of training is often an indicator for deficiencies of regional or national educational systems, which cannot provide enough adequately skilled workers.

We have observed characteristic differences e.g. between the sectors or between certain types of enterprises. But they may be reduced to one of three basic modes of vocational education and training predominant in our sample (ranked in order of incidence): (a) Internal training on the job and learning-by-doing; (b) recruitment of key workers on the external labour market followed by a period of training on the job; and (c) cooperative further training with other institutions and companies.

#### 3.2.4. Innovation

As already mentioned, one major task of the case studies has been to generate data that allow an analysis of the innovation characteristics and strategies of LMT firms, and that allow identification of patterns and similarities in behaviour. A necessary first step of this analysis was the search for issues that render comparison possible. After thorough study of the case study reports prepared by each of the national research teams, five such topics were identified: (a) the frequency of product innovations, (b) the utilisation of formal R&D in the course of innovation projects, (c) the nexus between product innovation and process innovation, (d) the degree to which innovation related activities are formalised in a firm, and finally (e) the degree of "distributedness" of knowledge and competence relevant for product innovations.

(a) The frequency of product innovations. All but one of the respondents rated product innovation as very important for their respective business. This did not come as a surprise because innovativeness was one criterion for the selection of cases and, moreover, because "innovation" is one of the powerful ideologies of the era. Being innovative is nearly a moral obligation in globalised capitalism. Nevertheless, there are remarkable differences in terms of the actual occurrence of permanent product innovations. Within the sample the extremes are, on one side, two metal working companies that manufacture to a large extent customised commodities and therefore every product may be more or less deemed a product innovation. Some of the furniture producers are also quite close to this edge of the scale. On the other side, there is one producer of standard paper where one finds hardly any product innovation at all; the specific competence of this firm is the ability to guarantee defined quality standards (cf. Bender 2005 for more details).

(b) The relevance of formal R&D for innovation projects. Most of the companies in the sample conduct internal product development, some of them even applied research. A few have formally established R&D departments though these are (by definition) small, others utilise external research establishments frequently. With the latter the forms of interaction range from rather mundane supplier-buyer relations, that is, a firm rewards a specified contract to an institute (e.g. to test material properties) to close collaboration of staff members with external researchers and with designers. It is not just engineering knowledge and competence these companies need and are able to "absorb" (cf. Cohen and Levinthal 1990) but also, sometimes quite basic, scientific knowledge e.g. in optics/physics (a producer of industrial textile), ergonomics (a manufacturer of pliers and other tools) or biology and chemistry (dairy firms).

(c) The nexus between product- and process-innovation. The question here was in how far product innovation and process innovation can be de-coupled in a given case. There are some examples in the sample where product innovation cannot meaningfully be separated from process innovation because the new product is a result of an innovative treatment of material. Likewise clear is the relation in those cases where a modification in design or the application of new materials (new for the company) more or less directly necessitates changes in the production process, of machinery and/or of competencies. Things are a bit less evident in the cases where a product innovation does not necessarily have an impact on the processes within the gates of the innovating firms but poses mainly logistical problems along the value chain. The main task product innovations entail in these cases is to concert the suppliers' activities.

(d) The degree of formalisation of innovation-related activities. With regard to only one company in the sample can one really talk of a somewhat systematic firm-wide planning of new products. Here the management tries to implement a strategic approach to product innovation: At the beginning of each year a few high priority projects are chosen by top management and corresponding target agreements are made with engineers and technicians. But more or less formalised product-development-procedures can also be observed in other cases. Yet there are also companies where new product ideas are to a great extent an upshot of not very systematic trial-and-error processes or of the individual intuition of, usually, personnel with "creative functions". A look not at the generation of new product ideas, but at how ideas are turned into products (or not) gives quite another picture. In a range of the firms, one finds rather elaborated methodologies to separate the (presumably) unworkable ideas from the others and to pursue the latter.

(e) The degree of "distributedness" of knowledge/competence relevant for innovation. This item is related to the concept of a distributed knowledge base as it is developed in Smith (2000). To simplify a bit, knowledge base means the knowledge a firm needs to be able to use to be successful in its business. When this knowledge is "distributed", it is not necessarily in the possession of a company but can be spread out between various actors and different levels of accessibility.

All but one of the case study firms use external expertise of one or more of the following types:

- *Suppliers of equipment*. Suppliers are sources of knowledge for all of the companies, though of differing degrees of relevance. When standard machinery is used, one may talk of a transfer of embodied knowledge to the firm. But in other cases the technology is either tailored or at least adapted to the companies' needs. This inevitably implies learning processes on both sides.

- *Suppliers of components/materials* are in some of the cases a second relevant source of knowledge. This pertains for those firms where the producibility of a component is a limiting factor that a designer of the end-product has to take into account. This is the norm, for example, when injection moulded parts are used. Here again we can see interchange and reciprocal learning between the end-producer on the one hand and the casting company and particularly the tool producer on the other.

- *Customers* are in most of the cases both an important trigger for product innovation and a relevant source of technological (user-) knowledge. What all of the cases have in common is that the sales and marketing people are the single most important interface to customer demands and hence a prior "gateway" for suggestions concerning new or improved products.

- Various kinds of *consultants* and *service providers.* The expertise of designers or test houses is fundamentally relevant for the core business of many of the companies in the sample. In addition, some of the reports highlight the relevance interviewees attributed to trades associations etc.

### 3.2.5. The concept of "innovation enabling capabilities"

Starting from the outlined experiences from the company case studies and drawing on the scholarly literature, the concept of "innovation enabling capabilites" (IEC) was developed (cf. Bender and Laestadius 2006). The intention was to introduce a tool that helps to identify organisational and cognitive preconditions (and deficits) for innovativeness *on the level of an organisation*. Needless to say, there are multiple conditions that can be identified on the societal level and on the level of individuals, and there is an interplay between these level (whereby one may conceptualise the latter as a fourth analytical level). Thus the IEC-concept focuses on a part of a very complex reality – but not on an insignificant one.

Systematising the diversity that the company case studies have revealed, we identified two analytical dimensions – transformative and configurational[6] – of IEC which are tightly interwoven empirically.[7] Note that we talk about capabilities of organisations, not of people. Knowledge and competence of individual members of an organisation are not yet capabilities in our sense.

*Transformative capabilities* constitute the enduring ability of an organisation to transform available general knowledge and competence into plant, firm or task specific knowledge and competence. This is a core competence particularly in LMT industries; the general knowledge on traditional industrial techniques such as welding is spread all over the world. The ability to transform it into a competence to generate zero-defect welding seams with complicated shapes or compound material is in many cases the specific feature of only a handful of firms worldwide, and one that separates the profitable firms from the rest.

*Configurational capabilities* constitute an organisation's enduring ability to synthesise novelty by creating new configurations of knowledge, artefacts and actors.[8] There are at least three aspects of configurational capabilities.

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[6] On first sight this bears some resemblance to Teece et al.'s (2000: 345) discussion of transformation and reconfiguration as part of a firm's organisational and managerial process aiming "to reconfigure the firm's asset structure, and to accomplish the necessary internal and external transformation". But they focus on transformation and reconfiguration of a firm's capabilities. The IEC-concept covers more than that as it draws attention to the fact that the adoption of e.g. distributed knowledge may entail not only transformations (and re/configuration) on the side of the adopting organisation but also of the adopted knowledge.

[7] Cf. Bender and Laestadius (2006) for a more detailed description including empirical examples from the PILOT company case studies.

[8] Our notion of configurational capabilities is somewhat similar to what Kogut and Zander (1992) call "combinative capability". Other than this it is also wholly in line with the fundamental argument in the Science and Technology Studies (cf. Jasanoff et al. 1995) that new technologies and innovations always entail a change

(a) Integrating over dispersed knowledge bases and areas. Success in innovation is, in principle, to a large extent based on the "*synthesising competence*" (Bender 2005) of actors, that is, on their ability to tap distributed knowledge and know-how from totally different areas and to recombine them creatively. This may include knowledge embodied in hard- and software, it may be scientific knowledge, design competence, or expertise in logistics; it may be codified knowledge or tacit knowledge incorporated in individuals or teams. It may also include mixes of science based knowledge with tacitness and crafts as well as mixing different scientific disciplines as is discussed in Gibbons et al. (1994). Capabilities to configure distributed knowledge may also have a temporal aspect: the ability to anticipate future customer needs.

(b) The second dimension of configurational capabilities – empirically tightly interwoven with the first – is an *organisational* one: the enduring ability not only to combine pieces of knowledge and technology but also to link actors together who possess relevant knowledge, technology and competence. This holds for smaller LMT companies in particular because, due to their limited resources, they are often not able to incorporate new knowledge sources by hiring specialists or buying appropriate organisations. Hence, they have to organise enduringly distributed "repositories" of relevant knowledge. That is to say, configurational capabilities include an organisation's aptitude to efficiently provide for access to and use of distributed sources of relevant knowledge and competence. This may be true in many cases involving the ability to cooperate with external R&D facilities or design labs. It also embraces an organisation's competence to manage logistics in a timely and flexible manner.

(c) The third dimension of configurational capabilities is *design* competence. The act of creation performed by designers and by engineers belongs to a large extent to the same realm. The basic idea is to achieve fitness between two entities: the form and its context. This act of creativity, i.e. configuring and modifying artefacts to meet certain needs and expectations, has no necessary relation to recent scientific advances and is an important activity all over the innovation process. (See section III 1.2., above.)

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in networks of social relations (see point (b) in the text). Innovation is not merely a scientific or technological process with economic consequences (and presuppositions) but normally implies changes of heterogeneous configurations and social relations.

### 3.3. Conclusions and Policy Implications

Notwithstanding the vast variety of characteristics, structures and problems covered by the term "LMT company" some general conclusions may be drawn on the basis of the case study analysis within PILOT.

In many LMT companies, the bundle of skills workers need to possess is changing; craft based competences and skills are frequently (though not throughout) becoming less important or obsolete while at the same time the ability to operate computer controlled machines is becoming more important. Currently, however, there is an absence of the provision of this type of hybrid qualification, a lacuna that contributes to recruitment problems. The lack of tailor-made curricula by education and training providers to address the gap in "crossbreed" qualifications exacerbates this problem.

In terms of policy, there is a need to examine ways to assist in providing access to the delivery of appropriate curricula to LMT firms either in-house or through some other mechanism. Those employees currently not usually participating in such further vocational training should be targeted. Perhaps especially in the first years of employment – as training in-house might represent a significant drain on the company – financial aid from the state or public agencies would facilitate the hiring and integration of more workers, especially young people.

R&D focused innovation policy instruments fail to address the deeper concerns and needs of LMT companies' innovation activities. This is obviously of concern to the firms themselves that do not find support in the innovation policy system, but it is equally serious for policy makers in their attempts to increase the overall level of innovation activity in the economy.

The concept of "innovation enabling capabilities" developed within the PILOT project poses searching questions for innovation policy makers. At the most basic level, the greater the creativity and design capabilities of firms, the more innovative they will be, whether they be in LMT or high-tech industries. How can firms be encouraged to build up these capabilities? What roles could different actors play? How and at what level can the development of transformative and configurational capabilities be supported?

## 4. Value Chains and Regional Embeddedness

The third empirical topic of PILOT research was the importance of relations along the value added chain and of local embeddedness for the competitiveness of LMT firms. Each partner choose one company out of the case studies just described for further analysis and investigated the nature of that firm's relations with clients and suppliers (focusing on the "value chain" as the unit of analysis) and then on the company's web of relations – beyond this transactional environment – with other companies, agencies and institutions making up that company's "regional network".

### 4.1. Research Design and Methods

The value chain analysis was based on a series of interviews with the focal company, one client and one supplier. Interviews were semi-structured, based on a commonly accepted set of guidelines. In addition, for each of the companies studied in the value chain, researchers filled in a checklist regarding the nature of the relations among the companies and the degree of integration of the supply chain. Each partner prepared a "value chain report" based on the results of the interviews and this checklist.

Researchers then proceeded to map the companies' regional networks, interviewing executives of the firm and representatives of agencies and institutions (including government, technical schools, labour unions, business associations) that make up the focal company's regional network of relations. These interviews also were semi-structured, based on a common interview guideline. Partners produced a "regional network report" that attempted to gauge the degree of local or regional embeddedness of each company.

The results from the value chain and regional network reports were then compiled. The value chain checklists were used to generate two matrices on client-supplier relations, plotting each company on the graph according to the nature of its relationships with clients and suppliers and the degree of integration of the companies in the supply chain.

The analytical distinction between these two sets, however abstractly clear, is difficult in practical terms. For the sake of clarity we will nevertheless formally distinguish between the outcomes of the value chain and the regional networks analyses.

### 4.2. Results

#### 4.2.1. The value chain analysis

For our purposes "value chain" refers to a particular firm's transactional relationships, both upstream and downstream. That is to say, it includes not only the supply chain, but clients as well. By expanding the analysis to include the value chain, the quantitative and qualitative importance of outsourcing emerges. The companies analysed establish relations with a very wide variety of different kinds of suppliers. For this reason different kinds of supply chain architecture emerge, even in the same companies.

The value chain analysis made clear that some of the LMT companies play an important role in terms of innovation in high-tech companies. There are examples where the former, the user of the technology, pushed a high-tech supplier to innovate through requests to improve an already existing product, or develop a new one. For example, in the German paper industry, relevant impulses for innovation for chemical dye suppliers have come from paper manufacturers. In other cases, LMT companies (as measured by expenditures on R&D) are in a way high-tech companies in disguise, either through their capacity to modify high-tech equipment, or their involvement in product design and process innovation in cooperation with clients and suppliers. A metal die producer in Italy provides an example of this type of innovation through cooperation.

In general, relationships with suppliers and clients are important for knowledge generation and innovation. In many firms innovation is non-linear, has a highly tacit dimension and does not occur within the confines of one company's R&D department; about half of the firms engage in some degree of collaboration on design and/or innovation with their clients and suppliers. Thus the relationships between clients and suppliers often represent important nodes of knowledge formation and innovation. It follows that companies' ability to be innovative depends to a large degree on their ability to develop ways of managing their relationships that take advantage of the innovative capacity of these relationships (cf. above "configurational capabilities"). Companies that effectively manage the supply chain and build cooperative relationships with clients and suppliers (companies that move up the value chain towards greater value added) may very often not only see wider margins, but greater autonomy, new markets etc.

A focus on lead time reduction and cost control in the management of the supply chain does not automatically imply high levels of integration between the focal company and its suppliers. Often, though, suppliers are important – sometimes key – contributors to innovation, with innovation occurring as a result of cooperation between supplier and client. In this case, early involvement of the suppliers is crucial and a high degree of cooperation is a factor in strategic success.

In the case of customised manufacturing, cooperation needs to go yet a step further. Companies need to develop inter-functional project teams. Based on our research, project teams seem typically be established with the core competence of each company on a sequential basis. In successful cases, team members include all functions including purchasers, sales representatives, product designers, production managers and personnel at the shop floor. This is, for example, exemplified by one of the cases studied by PILOT's Norwegian research team.

Proximity is fundamental for some of the PILOT cases though not necessarily in the spatial sense: cultural (i.e. language, managerial culture) and/or organisational proximity (harmonisation of the level of technology, homogenisation of procedures, a similar approach to quality control) are more important in some cases than spatial proximity.

Conflicting tendencies regarding physical proximity and the supply chain emerge, depending largely on the type of product produced. On one hand, there are cases where the trend is toward greater globalisation of the supply chain. This is the case of global procurement, mainly when dealing with producers of standardised components. This dynamic implies an extension of the supply chain. On the other hand, where the relationship between clients and suppliers is based on just-in-time methods (with both high product complexity and a high degree of outsourcing), logistics is crucial; and when personalised, non-standardised solutions are required, as in the case of customised products, physical proximity between the company and its suppliers is important, if not essential. Similarly, when delivery time to the client is important, and the time allowed is short, physical proximity is required. Finally, where companies deliver custom solutions, and not just a standardised commodity, physical proximity between clients and suppliers may be of importance.

Tacit knowledge flows are of clear importance in LMT value chains. When tacit knowledge is crucial for competitiveness, proximity (both cultural and physical) becomes important. This is because practical knowledge is sometimes difficult to codify, requiring for example an exchange of personnel and temporary assignment of employees at the partner company.

Even when geographically far from the focal company, equipment suppliers are often important for both productivity and innovativeness in terms of knowledge-transfer. The relationship with the equipment supplier is important even without physical proximity. This is the case where, for example, established collaborative connections are close and investment volumes are high. Here, temporary assignment of workers to another company is not dependent on distance.

Another dynamic that emerges is the importance, in some cases, of "co-opetition" (cooperation and competition, or horizontal networking; cf. Garibaldo and Jacobson 2006) as a useful way of doing business. For example a firm that is unable to meet a particular order, rather than losing the client, may contract out that order to a competitor. This was the case with a precision-components manufacturer in Ireland, for example.

Increased integration is a challenge for many of the companies we studied. In particular, the importance of the greater use of both managerial and information and communication (ICT) tools emerges in cases where the value chain has been internationalised to a relevant degree. Nonetheless, the use of ICT tools and portals for managing relationships through the value chain is quite rare in our sample.

While stable and long-standing relations are the main means of selecting the right suppliers, and of building trust and co-operating efficiently, the use of methods and instruments for evaluating the performance of suppliers also emerges. This practice was used by one of the Polish companies examined. Where such evaluation is important, it is best used in ways that enhance the ability of companies to build relationships of trust and cooperation. Unless evaluation systems are designed to help suppliers improve their performance, companies run the risk of ending up with a high rate of supplier turnover.

Almost all of the SMEs in our cases are embedded in their local contexts through financial and structural constraints. Many SMEs are facing crises because of both the globalisation of the economy and the stagnation of GDP growth in Europe. In this context, horizontal, virtual networks among suppliers emerge in certain clusters as competitive strategies. This new form of organisation seems to boost the competitiveness of SMEs.

Regarding SMEs specifically, the analysis of the value chain relations indicates that in many cases institutional infrastructure and public goods are essential for their competitiveness. Often SMEs require supplements to their informal, tacit knowledge base in the form of R&D-competences and more systematic basic research and development. In addition, external institutes, universities and associations are important for boosting innovation, quality assurance and vocational training.

An analysis of the value chain relationships of the companies studied also shows that firms in open and globalised markets that want to increase competitiveness often do so by "moving up" the value chain. That is, they produce a greater share of total value added, rather than focusing primarily on time and cost reduction. Because of the fact that companies normally co-operate with partners (like clients, suppliers of components, suppliers of raw materials, suppliers of equipment, etc.), the nature of established relationships with actors shapes company capabilities to both acquire and contribute to creating value. In that sense the nature of the relationships contributes to competitiveness.

Our research suggests that companies that move up the value chain are generally more competitive and enjoy a higher degree of autonomy. They are often able to compete with firms in low-wage countries by providing just-in-time solutions, customised products, services including design, and by participating with their clients and suppliers as partners in product and process innovation. Companies that move up the value chain may free themselves from dependency on one or a few clients, increase product lines and services provided and open up new markets. Thus, suppliers who were previously interchangeable for lower-cost competitors can make themselves indispensable.

Moving up the value chain implies two processes. On the one hand, companies tend towards greater integration with their clients and suppliers. For example, more information is shared, there is continuous consultation among members of the supply chain, and companies even co-invest in their suppliers. Procedures are streamlined as companies in the supply chain adopt the same systems, and ICT and business-to-business (B2B) portals are employed to greater and greater degrees. On the other hand, companies build stronger, more collaborative relationships with their clients and suppliers. There are of course exceptions. However, for several of the companies increased levels of integration and collaboration with their clients and suppliers is a question of survival.

The growth of internationalisation and outsourcing processes in open economies requires that companies increase their capability to act through extended and globalised organisational forms like the virtual enterprise. For this reason the capacity to manage ICT tools for the support of relationships between companies and partners is needed. While firms have lagged in terms of introducing supply chain management platforms (ICT, B2B portals), there is a tendency towards more inter-firm collaboration.

### 4.2.2. The regional network analysis

On first reading, the national reports on the regional networks of the PILOT case companies suggest very different situations, with little basis, if any, for comparison. This impression changes dramatically if we switch the conceptual frame of reference from a static to a dynamic perspective. Through this switch, a story emerges of processes in train – for example that LMT firms are increasingly international – in some, and probably all the European countries. Strategic alternatives available to policy makers and the main social and economic actors are suggested. To make this "switch" possible, a set of concepts must be introduced that explain the interplay between globalisation dynamics and forces of localisation and embeddedness.

**The role of geographical proximity**

The importance of economies of scale is well known (Marshall 1890) but it is not the only factor shaping the way firms operate. The concept of "external economies" introduced the idea that some interdependencies exist between the participants in an economic system, which do not operate through the market mechanism or that are not completely mediated by the market process. These externalities can be negative, as with pollution, or positive, as with knowledge spillovers. Typically, the positive externalities are external to the market and are related to co-operation and co-ordination. Special examples of externalities are transaction costs. This relates to the concept of network in terms of the explanation of growth and economic change. The more integrated the network, the greater the positive externalities arising from reductions in transaction costs. Information and knowledge have become valuable in providing a strategic advantage, from both distributive and production organisation perspectives. Where shared, they become an important part of the "productive basis" of wealth.

As a result, there are two different drivers in play, one exploiting economies of scale based on local agglomeration, the other exploiting external economies due to the general progress of the industrial environment. In the first case the focus is more on social, embedded and mostly non-physical features – what is also called contextual environment; in the latter the focus is mostly on non-spatially constrained and on physical and non-physical features – partly coinciding with the "transactional environment" (cf. Trist 1976). What the net effect of the two drivers is, depends on the specific situation of each locality.

Now, whereas there is greater consensus as to the relationship between business organisation and transactional ambient, the relationship with the broader ambient is seen indiscriminately as background and, at most, the place of possible constraints on the business activity. In the past decades, there have been contributions from the most diverse disciplinary fields – ecology, economics and sociology with an institutionalist orientation, the Italian tradition of analysis of districts, etc. – offering a reassessment of the salience of the contextual ambient which appears to be anything but undifferentiated and with a much more strategic role than that of setting constraints.

A broader view can be introduced, taking into consideration the effect of globalisation processes.

**Deconstructing and taking roots: globalisation – 1**

There are very simplistic narratives of globalisation on both sides. On one side globalisation can be said to be a process of overwhelming quantitative and qualitative homogenisation of the world. It means for instance that every kind of idiosyncratic feature – such as food, clothes and entertainment – will be more and more disregarded and lose any real market relevance; the manufacturing process will become more and more mobile, as cultural and social differences at the national and sub-national level among different nations or regional areas diminish. On the other side it can be argued that "places" matter and, in the long run, only some activities will actually be globalised. A conciliatory view was introduced with the word "glocal" to stress the very positive and optimistic view that the two drivers can support each other in some kind of virtuous circle. "Glocal" is an omnibus concept with very little, if any, analytical power. A realistic account of globalisation is different.

Our starting point is Storper's contribution (Storper 1997) on the relationship between an "economy of flows and substitution" and an "economy of interdependencies and specificities". The first case occurs when resources would flow between parts of a firm, between places, without having any particular dependence on a particular place. This is exactly the reverse of the concept of a territorialised or embedded economy in which economic activity is dependent on resources that are territorially specific. The second case is the ideal-type of a pure territorial economy in which specificities that are strongly territorialised and where the supply of these resources is subject to important inelasticities. It is of course the case of the existence of relations of proximity, of agglomeration, etc. (cf. Garibaldo and Jacobson 2006).

It should be noted that the concept of embeddedness is broader than geographical proximity and agglomeration; it implies a specific contextual environment – made up of social institutions, conventions, trust, etc. – allowing people to exploit both economies of scale and external economies in a very idiosyncratic way. This is the case for example of very high quality goods, those that involve technological innovation or ongoing rapid differentiation, or highly specialised services. What is relevant is that this condition is not necessarily in total contrast with the process of globalisation. In fact, some firms that we have analysed have been very smart in taking advantage of this possibility.

The actual existence of these two ideal-types in a pure form is very rare; in the real world there are many different hybrids, but it is analytically possible to trace them back to one of the two models.

If these are the basic concepts useful for our inquiry, what kind of dynamics can be highlighted in the process of globalisation? It is not a single and homogeneous process of substitution of the second ideal-type by the first. There are at least four different possibilities as Figure 3 shows.

**Figure 3.** Territorialisation and internationalisation

| International Flows in Production System | Territorialization of Production System: High | Territorialization of Production System: Low |
|---|---|---|
| High | (type 1)<br>Intrafirm trade with asset specifities<br>Intermediate outputs of FDI<br>Intermediate markets served from territorial cores<br>Industrial districts | (Type 2)<br>International divisions of labor (e.g. in routinized manufacturing)<br>International markets (e.g. in consumer services)<br>Interfirm and interindustry trade without territorial core |
| Low | (Type 4)<br>Locally serving production to specialized tastes with low international competition | (type 3)<br>Local commerce in basic services not delivered via big-firm hierarchies |

Therefore, there are many different dynamics and strategies for each firm and sometimes more than one option, at the same time, for each firm, as in the case of the multi-utilities. The standard account of globalisation stresses the importance of the movement from type 3 to type 2 and from type 4 to type 2, that are of course actual trends. The "true" process of globalisation – as different from the old process of internationalisation – is the dynamic from type 1 to type 2. Regardless, one of the most important consequences of globalisation is a reinvention and re-functionalisation of the uniqueness of some places; in these cases, the concepts of economies of scale and external economies, of transactional context, etc., will come again to the fore.

To summarise, from a more realistic perspective, globalisation is a process of dynamic connections mostly of previously embedded economies; the setting up of these new and broad connections leads to a new positioning of these economies – national or sub-national – that can produce both a destructuring of their territorial features or a different kind of embeddedness. There is a formation of a new global context. The very existence of a division of labour on an international scale is not brand new in itself – this was the starting point of both Smith and Marx. In the 19th century there were very good examples, for instance the cotton industry that brought distant places together in a single division of labour. What is now unique to this new global context is the transnationalisation of firms through the consolidation of a world-wide intrafirm division of labour.

When we analyse the firms in our sample according to this framework, our regional reports show cases distributed in all four quadrants. The dynamic trajectories from the past and towards the future show clearly that the main trend is towards type 1 and type 2. A first conclusion therefore is that the equation "LMT industry = local embedded processes" is not tenable; while some of our cases are on a highly embedded, self-contained trajectory, others are not. Another conclusion is that the equation "LMT = structural weakness to globalise" is also wrong; some of our cases provide evidence of strongly embedded processes but are nonetheless able to gain a global market position.

The concepts of economies of scale, external economies, transactional and contextual environments can be taken now into consideration in relation to our sample. At first glance in all our cases external economies play a role, more or less relevant depending on each national or regional situation. Firms in a poor or restructuring environment have particular problems; where there is potential for growth, policy makers should intervene with a comprehensive policy acting on all the levels of our analysis – contextual, transactional environments and external economies to set up a virtuous circle. In an economy dominated by high levels of international flows and low levels of embeddedness, globalisation can become a driver of a process of institutional restructuring and repositioning in order to make a given territory more open and favourable to the process of globalisation itself. In this case both the solidity and variety of the local institutional set up is of importance. Factors such as specific national, sub-national or EU policies play a very important role both in supporting the development of economic activities and/or repositioning and adapting previous activities. Other important factors are institutions related to the labour market, such as vocational schools, intermediate institutions in the field of organisational, technological and scientific innovation and highly informal factors such as networking based on trust.

**Concentration and dispersal: globalisation – 2**

In her seminal analysis dating back to 1984, Sassen (2001), on the basis of empirical evidence, says that the globalisation of economic activity entails a new type of organisational structure. Global cities and global city regions are elements of this new architecture. Global cities are the place of the new financial activities and of the new services in support of the process of globalisation. Global city regions are the places of the headquarters of transnational firms. Here, as in the case of large manufacturing complexes like the auto industry, national identification tends to be stronger. In the new global organisational structure, centrality still matters. The destructuring and reinvention of organisational structures due to globalisation does not imply the disappearance of regional spaces, but a redefinition of them.

The new type of region is still a geographic entity and it cannot exist without the old sub-territorial entities and infrastructures that are "encapsulated" in the new structure, or, to reverse the proposition, the new grid is embedded in the old structure. Then there is a different kind and level of centrality. Networks of major international business centres constitute new geographies of centrality. A new hierarchy of overlapping circles, based on the nature of the globalisation process is growing. There is a world-wide transterritorial network, linked to "continental" networks, such as the European one, each of which are connected to "regional" networks. Some of these centres simultaneously belong to more than one circle or network. They deploy a thick matrix structure that is partly transterritorial, partly virtual, partly territorialised and partly highly territorialised. There is therefore a concentration of decision making power in few centres, even if there is a highly indented situation that seems to be a dispersal of the power structure.

The novelty is not the fact that the world is interlinked but that there is a shift from a system of nested scales to a transcalar one; that is, to a system connecting scale-based, independent or partially overlapping systems, thereby linking different levels of different scale-based systems, independently of their own internal hierarchy. New social and economic dynamics are at the fore. So, while it is clear that globalisation is important, to understand the particular relationship between a place, including its production system and related social context, the specificities of the place must be examined in terms of the various ways in which it interacts with the global. The nation-state will have to renounce its exclusive right to power over its territory, but it will not disappear.

It might be argued that there is a contradiction between the importance of place and the "digital revolution". If any kind of data or information is at the immediate disposal of everyone, everywhere why is it still so necessary to physically agglomerate? There are many different possibilities: on the one hand economic activities can take root and become more embedded; on the other they may dis-embed from the local dimension. The first possibility may induce levelling, the latter creates new hierarchies. But the main trend, based on market forces, is toward the loosening of the local dimension and setting up new hierarchies of places. Besides, ICT based networks, when installed, will follow path dependent trajectories that will constrain the degrees of freedom open to the actors.

The sample analysed in the PILOT project is not geographically distributed in or around global cities but partly in global city regions and in new regional or sub-regional centres. In this case "regional" is a subdivision of global and not the administrative unit of a country. In some cases the dynamic is very interesting: a process of redefinition of the global hierarchies of different places is quite evident. Our sample is a very good illustration of the dynamic of centralisation and dispersal, of the redefinition of centrality and hierarchies among different places, etc. It is also evident in many cases that there are trans-scalar processes at play. Are there policy implications?

### 4.3. Conclusions and Policy Implications

The first really critical policy indication is of the overwhelming importance, for a balanced dynamic between global and local, of *local policies* operating on the entire set of "environments" to which a firm belongs. This is relevant not only for the reason already illustrated above, the virtuous circle, but to create the possibility for low-tech and medium-low-tech SMEs to act at the different scales without losing a distinct asset, that is a transition from whatever quadrant of Figure 6 to type 1. For SMEs this is a very difficult task and some specific policies can support it. For instance the setting up of what in the international literature is defined as a *virtual firm*, that is a network configuration of independent SMEs able to cooperate in delivering to the market complex products and services, can be helpful. These kinds of processes need a leader taking the initiative, so they cannot be simply planned from above, but they need suitable policies to ease the start-up process and increase the chance of long run sustainability.

A second policy problem is the *circulation of knowledge*. As we have already argued, many LMT firms are frequently utilising high-tech knowledge in original and often informal ways. In the best of cases, they not only utilise knowledge produced by high-tech firms to innovate their businesses, but also produce a feedback process of innovation that can be codified knowledge as well as incremental, non-codified knowledge that adds value to their own businesses. Learning by doing and learning by using are the methods allowing theses processes to develop.

To facilitate these processes of knowledge exploitation the presence of a dense network of institutions favouring knowledge circulation is critical. This does not imply that the only scale for circulating knowledge among low-tech and medium-low-tech SMEs is the local or national. There are also examples of international circulation. The point is that there is a big difference as to whether the transfer comes from within a corporate scheme, from within a sub-supplier relationship, through taking advantage of institutional aid, or because of a cooperative scheme. In the last two cases the capacity of low-tech and medium-low-tech SMEs to exploit knowledge resources on their own will develop with time and it is probable that some of this knowledge will spill over to other firms. The policy problem is, therefore, to support the *building* of innovation-enabling *capabilities* for these companies to access knowledge resources in a critical and selective way. Such policies can also be implemented through networking techniques; in this case the network is not a functional operative scheme among firms with which to deliver products and services, but a way to cooperate between firms and agencies in order to reach specific objectives. Examples of this kind of network include shared facilities for product innovation or a policy coalition lobbying for particular policies, for instance specific vocational policies to strengthen the labour market.

Using any set of indicators, LMT firms can be classified as highly dispersed. Our research shows us the overwhelming importance of the strategies and the specific set of managerial capabilities firms need to cope with the main threats to low-tech and medium-low-tech competitiveness: a) a new international division of labour, based on the globalisation process, led by cost competition; b) a devaluation, in the global value chain, of the manufacturing activities that are the main feature of LMT firms.

Successful LMT firms are going global though different paths either by strongly reducing their own degree of embeddedness in a specific territory or utilising it as a competitive asset. Whether adopting the latter strategy has to do with being an SME should be investigated further. The first strategy is sometimes very complex because it seems that successful firms following this path are aiming for a mix of embedded and non-embedded elements. The rationale is very clear: to utilise embeddedness to shape a specific product/service asset in the global scene while at the same time dis-embedding the provision of standardised products/services. Designing the proper mix is quite difficult.

The second strategy stems from the simple fact that in a global world there are broad sets of products and services whose value depends on being associated with some kind of uniqueness. A clear example can be a specific sector, such as food, but also a traditional pairing of some product attribute – for instance quality or reliability of delivery – with a country or a region. In this case, too, the strategy is not simple because it cannot be the mere continuation of a tradition; the same "content" should be made available according to new standards.

The devaluation of the global value chain is a very difficult strategic issue that must be confronted. Generally speaking the overall process of concentration in most business activities leads to a restructuring of the value chain with a trend towards a devaluation of the manufacturing activities in favour of the final producers or distributors. In this case the position along the value chain is of critical importance. LMT firms are distributed at different levels so no single recipe exists for all. Basically the ones in the upper part of the value chain are not so keen on designing new strategies for moving up the value chain. For the others, moving up can be a matter of survival; moving up means acquiring the ability (managerial capability, organisational renewal and workforce skills) to handle customised product/service innovation. This presents the problem of a new degree of integration with clients and suppliers. What is really new is the fact that generally clients and in many cases also suppliers are no longer bound by geographical proximity, so again the problem is to cope with the globalisation trend. The conclusion of our research is that, taking into consideration the different interests of LMT firms depending on their actual positioning along the value chain, our cases show a low level of integration in comparison with the main trend in the industrial sector.

OEMs, and more generally, firms at the top of specific production chains, are looking at some kind of closer integration with specialists and first tier suppliers, the so-called integrators; to decide how close, if at all, an LMT firm should be to other firms is of course a difficult choice but this is today one of the critical strategic choices to be made. The evidence suggests that most of these firms will have difficulty making this choice because it implies a general restructuring of their businesses and therefore new managerial capabilities, a different and more sophisticated organisational structure and, in many cases, new skills for the workforce.

The importance of making the right strategic choice depends of course on each firm's capabilities. Based on the results of our research, in order to achieve a balanced dynamic between global and local, *local policies* aiming at the creation of public goods supporting the innovation process should be stressed. Clusters and fragmented economies need strong intermediate institutions and institutional infrastructure to provide local collective goods. To set up such institutions, the positive combination of the vision of the public bodies and the interests of the stakeholders (collective actors) are important factors. The crux of the argument is that technological evolution and innovative capacity evolve among other things due to the social context. Generally firms, and particularly small and medium sized LMT firms, are very sensitive to the solidity of the institutional set up both of the national and of the sub-national specific dimension. "Solidity" here means a mix of available physical infrastructures and of educational, vocational, knowledge creation, diffusion and brokerage facilities and institutions.

Lastly, our research reveals the importance of the positive coupling of the presence of LMT firms with the long standing economic and social sustainability of an industrial sector in a specific country or region. There are two main reasons for this positive association. First, the employment factor: until now and for a long period to come, the employment multiplier of the manufacturing sector in general, and thus of LMT firms, is one of the highest among many different industrial activities. A decline of these firms in a specific territory will lead to a high level of unemployment. The second reason depends on the very peculiar role of LMT firms in the knowledge dynamic. They channel, intermediate and fuse two different flows of knowledge: one based on social capital, the unique or the idiosyncratic feature of a specific industrial culture, which is mainly tacit; and another coming from the scientific and technological development on a broader societal scale and mostly global, which is due to *the general progress of the industrial environment*, which is mainly codified. The fusion of these two knowledge flows produces new tacit and new codified knowledge. It is not a spontaneous, linear and automatic process, but depends on the societal environment, on the soundness of the industrial environment, on the sophistication of the organisational setup, on the nature and the scope of the workers' skills, on the nature and the effectiveness of the co-operation among the different actors at the micro, meso and macro levels, on the soundness of the firms' strategies, and ultimately on public policies.

## 5. Policies for LMT?

The broad aims of the policy focused section of the PILOT project were to examine how policy impacts on the deep, complex and systemic knowledge bases that contribute to innovation and knowledge creation in LMT industries; and to contribute to policy on restructuring by making policy suggestions, at appropriate governance levels, which will further the economic and social cohesion of Europe. At the outset of the project, we hypothesised that many policies, at various levels, even those not explicitly focused on LMT industries, may have an influence on those industries. We expected the nature of this influence to be diverse; among other specific impacts are those on innovation and knowledge formation in LMT industries, the key focus of the PILOT project. We further hypothesised that policy towards innovation and knowledge formation in LMT industries could be improved.

### 5.1. Policy Objectives of the PILOT Project

Given these broad aims and perspective, one of the main objectives of the PILOT project was to make policy recommendations for the promotion of LMT sectors (cf. section IV). In order to achieve this goal, the specific objectives were:

- to identify the main policies that impact on innovation and knowledge formation in LMT industries;

- to compare current policies towards LMT industries among the countries and regions of the EU;

- to propose a range of possible policies and/or policy related initiatives for innovation and knowledge formation in LMT industries.

Guiding these objectives was the conviction that policies of all kinds – and at all levels – both explicitly aimed at encouraging innovation, and more generally impinging on industrial development, have an impact on LMT industry competitiveness and viability. Prior to PILOT, the nature of the interaction of these policies and what their net effects were on LMT industries had not been clearly examined. These omissions were partly consequences of the focus among social scientists in recent years on high-tech industries. Another consequence was a paucity of studies on how policies may be developed so as to facilitate innovation in LMT industries, including through interactions between LMT and high-tech industries. The methodology adopted and data sources used to gather policy-related information for the PILOT project are outlined below.

### 5.2. Methodology and Data Sources

#### 5.2.1. Methodology

The first task was a review and analysis of innovation (and industrial, enterprise) policy documents, statements and strategy documents at EU, national and where appropriate regional level. Alongside this, the methodology chosen to address the objectives involved using a variety of actors to help identify, analyse and comment on the relevant policies. For the analysis of policy documents, the principal approach used by the research teams was to "follow-the-money" and identify the essential focus of the policy programmes and initiatives that received the bulk of available funding.

The generation of information on policy from the various actors took two main forms. The first involved either structured and/or semi-structured interviews with individual policy-makers/influencers in various institutions and organisations. The second source of information was the case studies of LMT firms (cf. III 3.). More specifically:

- The first level on which research on the identification of relevant policies was undertaken was that of the policy-makers in policy institutions. The target policy-makers included those at local, regional, national and EU levels, in industrial and development agencies, industry associations, trades unions, municipal authorities, central government and European agencies. Structured interviews took place in these institutions in the countries of the partners involved in this work pack age. Therefore, this approach explicitly differentiated between the various levels of political governance, local, regional and national and European. For the local level, for example, policy makers in the municipal or other local authorities were inter viewed to obtain information on their perspectives on the particular policies. Interviews with the policy makers at the appropriate level were supplemented with any documentation that existed on policies. In particular, the partners were asked to re view innovation, industrial and regional policy documentation in their respective countries.

- Second, results from the company case studies in which decision-makers in the firms were asked to identify the nature and level of the policies that affect their firms and industries most significantly were incorporated. *How* these policies affect their firms and industry – e.g. positively or negatively – was also a question. Contributions from the regional studies (cf. section III 4.) on the impact of policy on LMT networks and value chains also informed the process of identifying the policies that impact on LMT firms.

Therefore, the empirical policy-related component of the PILOT project can be described as a study of relevant policies from the policy makers' perspective, refined by the results of firm decision-makers as reflected in the findings of the case studies of firms and the contribution of the results on the interplay between policies and networks and value-chains in LMT industries. As outlined above, these findings are complemented by a review and analysis of policy documents in partner countries, interview with policy makers and other stakeholders, and contributions from the theoretical and empirical literature on innovation and innovation policy.

### 5.2.2. Data sources

Apart from the Work Package coordinator, DCU, six partners in the consortium were explicitly engaged in empirical work for the policy section of the project[9]. There were, therefore, seven individual policy reports generated for the project. These documents are, of course, complemented by the policy-related material that is derivable from the empirical work carried out for the 43 company case studies in eleven countries and the information on policy aspects derivable from the network and value chain analysis, which was supplied by eight PILOT partners. The aforementioned seven policy reports differed in their coverage with some focusing solely on innovation policy and others giving a broader policy perspective[10]. In addition, some of the partners were asked to focus solely on a regional/local policy level rather than national level[11]. Moreover, the Work Package coordinator had the task of interviewing people at EU level, specifically personnel within DG Research and DG Enterprise and Industry. There are also policy pertinent findings, analysis and suggestions from the quantitative work (cf. section III 2.) that are included, where relevant, in the overall policy conclusions of the project.

In relation to policy issues there are two general findings. First, the research found that there was a combination of low levels of knowledge about policy among LMT firms and a disproportionate attention on the part of policy makers to science and research-based innovation and especially R&D. Moreover, despite some improvements in the sense of cross-fertilization between academics and policy makers, at the level of policy the difficulty in measuring the type of innovation most prevalent in LMT firms tends to result in less attention being focused on it. Nevertheless, it is clear that there is a need to devise policy measures that improve the knowledge base and capabilities of LMT companies, assist interaction among firms and other actors, and encourage the generation and diffusion of knowledge between high-tech and LMT sectors and encourage interaction between those sectors.

The second general finding was that, specifically in relation to most of the new member states of the EU, the PILOT issues cannot be understood without clear reference to the recent transition of most of their institutions. The impact of their history on the performance of their economies, and their enterprises specifically, needs to be fully understood as a prerequisite to devising policies that meet the needs of LMT, and other sectors, in those economies.

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[9] STEP, UDTM, OUVE, AIER, FILOV and UJAG.
[10] STEP and AIER – Innovation Policy; UJAG, OUVE, DCU – Overview of General Enterprise, Innovation and Regional Policy
[11] DTM, OUVE and FILOV.

### 5.3. Results

#### 5.3.1. Policy document review

A review of EU, national and where appropriate, regional level innovation and industrial policy documents using the "follow-the-money" approach showed that although, as a generalisation, none of the policies showed any systematic discrimination against LMT sectors, most of the available funding is directed towards R&D effort in the policy mix.

The continuing weight put on such indicators as the 3 percent Lisbon target is evidence of this focus. This is not to say that R&D is not important, but that other important factors seem frequently to be ignored or dismissed. The separation within the echelons of the EU Commission between research and innovation is further evidence of the bias. There is a Commissioner for Research and a DG for Research with its own building, a huge staff and, among other things key responsibility for disbursement of the Framework Programme funds. Innovation, on the other hand, is the responsibility of one of the nine sections within DG Enterprise and Industry. It has a relatively small section within DG Enterprise and Industry, and a relatively small part of the EU budget.

#### 5.3.2. Case study firms and policy

An important finding of the PILOT project is that there is very little awareness among LMT firms of innovation generating policies other than those focusing on R&D. The policies that were viewed as helpful or positive by firms were mostly general policies implemented at national level providing tax incentives and subsidies for activities such as training, innovation and the hiring of personnel. In addition, encouragement to promote cooperation was viewed positively, and in some cases policies directed at environmental issues was viewed in a positive light. At a local level, support for initiatives such as technology parks was reported as constructive. At the EU level, programmes such as Adapt and Eureka, and more generally, any funding available from the EU was considered helpful.

Policies that were reported by firms to have a negative impact took two forms. In terms of general national policies, complaints included the bias in favour of high-tech firms and/or other sectors, the additional costs imposed by environmental regulations and restrictive regional or spatial policies. At EU level, the co-funding requirements for availing of EU funding, and the implications of competition from new member states for EU funding were identified as problematic. On a more specific level, policies that were identified as having a negative impact included inadequate training provision given the skill needs of LMT firms, and the absence of adequate funding to encourage the mobility and employment of key personnel.

Firms were also asked for their opinion on what policies could be implemented in order to help innovation and the development and sustainability of competitiveness in their firms. What emerged was that some firms suggested there was a need for a sustained, predictable, pro-innovation policy. It was also reported that there was a need for the development of a 'hybrid' skill certification, as many existing training providers did not offer training appropriate to the needs of LMT firms. In many cases, firms identified the need for help in changing the image of their industries and/or easing the employment of immigrants in order to redress the recruitment problems in their industries. There was also a call by some firms for policies, or publicity about policies, on networking. There was also a suggestion that a mechanism should be devised to help final year students to investigate companies' technological problems. Finally, the implementation of a local LMT innovation policy and training for EU funding applications were identified.

#### 5.3.3. Firm capabilities and policy

Another part of the PILOT project, utilising the case study material, also has something important to say about policy. Based on an analysis rooted in the dynamic capabilities approach, which emphasises the heterogeneity of firms, Bender and Laestadius (2006) introduce the concept of "innovation enabling capabilities", to describe the cognitive, organisational and material abilities a non-research intensive firm has to develop in order to be able generate profitable innovations. They distinguish two analytical dimensions of such capabilities – transformative capabilities and configurational capabilities (cf. section III 3.2.). Evidence gathered from the case study companies confirmed that none of them based their competitiveness on recent scientific findings. For these firms, innovation is the result of the transformation and reconfiguration of well-known knowledge, components and technologies developed elsewhere. These knowledge formation processes are similar to those found in high-tech firms. Therefore, Bender and Laestadius (2006) argue that the concept of "innovation enabling capabilities", although developed for LMT firms, may be useful for science-based innovation also.

Once these "innovation enabling capabilities" are identified, the next question from a PILOT perspective is: what are the policy implications? There are two main considerations. First, how can firms be encouraged to build up these capabilities? What roles could different actors play? Second, how and at what level can the development of transformative and configurational capabilities be supported? As both transformative and configurational capabilities entail learning, policies that facilitate learning in all its dimensions are important.

From a similar theoretical perspective, analysis of LMT firms' choices of relation-ships within networks and along the supply chains Garibaldo and Jacobson (2006) suggests two key, inter-related capabilities. The first is the capability of forming medium-to-long run, sustainable relationships that involve sharing knowledge. The second involves knowing when and how to choose between such relationships and arms-length, market-based relationships. The PILOT evidence suggests that both the relationship capability and the higher order relationship-choice capability are important for innovation and competitive success.

Again there are policy implications and again they are in the areas of support to encourage the development of these capabilities. Management training may be an important element in such development but is probably not sufficient. As for transformative and configurational capabilities, so for the relationship capabilities, policies must facilitate organisational learning as well.

### 5.4. Policy Conclusions

#### 5.4.1. Policy towards innovation in LMT industries can be improved

Relative to funding for R&D and science-based innovation in general, both at the EU level and at the various levels within member countries, very little explicit policy attention is paid to innovation and knowledge formation in LMT industries. Therefore, policy towards innovation and knowledge formation in LMT industries can be improved by becoming more tailored, designed to conform to market processes and by being inclusive.

#### 5.4.2. Policy needs to be tailored

Both the general literature and PILOT-based information specific to regions suggest that policy should be tailored. In general terms, the imitation of policies that appear to have been successful in other countries often leads to the neglect of important characteristics of national innovation systems not being taken into account. Innovation and industrial policy, if it is to be effective, has to focus on the specifics of every system and take into account the way in which innovation processes are contextually specific. Policy has to be tailored to specific sectors and develop competencies that are specific to the local/regional context. This argument can be easily extended to the promotion of clusters or development of localised learning policy. As regions are embedded in different national economies and national systems of innovation, localized learning policies cannot be easily copied from region to region.

In a more specific PILOT context, Bardi et al. (2005) reiterate the importance of local policies that operate on the entire set of environments to which a firm belongs, in order to create public goods to support innovation processes. In particular, strong intermediate institutions and institutional infrastructure is needed to provide local collective goods.

A second policy problem identified by Bardi et al. (2005) is the circulation of knowledge – the notion that LMT firms use high-tech knowledge in original ways and often informal ways, and then combine that knowledge with in-house tacit knowledge to develop new knowledge combinations, which through feedback mechanisms, in turn, influence the development of knowledge in the high-tech sector. The argument is that there is a need for a dense network of institutions, not only at local or national level, but also at international level, to facilitate the circulation of knowledge. From a policy perspective, therefore, there is a need to support capacity building in LMT firms to provide them with the capability to access knowledge resources in a critical and selective way. Such policies could be aimed at promoting networking, for example, to create shared facilities for product innovation, or to set up a coalition to lobby policy makers. They should also aim at the need to distinguish between situations in which such networking is appropriate, and those in which arms-length, market-based relationships are appropriate.

This is close to the argument about the need to encourage the diffusion of innovation between high-tech and LMT sectors in order to ensure the maximum innovativeness of the economy as a whole (Robertson and Patel 2006). The argument is based on the explicit recognition that the non-high-tech sectors provide markets for high-tech products and encourage further investment in R&D. The new knowledge that arises from the combination of high-tech and LMT knowledge in LMT firms, feed back to the high-tech sector as a source of, and input for, further innovations.

Within this general view a paradox emerges from the PILOT material. It has been argued that policy – whether it is to promote localised learning (Lorenzen 2001) or industrial policy in general (Navarro 2003) – should follow a bottom-up approach. In other words, policy makers should be attentive to the needs and demands of firms and the starting point for policy action should be at the firm level. However, it emerged from the PILOT case studies that many of the firms did not feel that they could influence policy towards their firms or industries and/or that the appropriate institutions to facilitate such feedback do not exist. The solution is for more regular, firm-specific research to be undertaken, and/or for mechanisms specifically for facilitating the bottom-up flow of information to be set up.

### 5.4.3. Policy should conform to market processes

This principle really means that policy should be designed in accordance with our present knowledge of learning processes (Lorenzen 2001: 169). In other words, as pointed out by Maskell et al. (1998), "policy-makers should take account of what goes on at the 'bottom': recognize firms as experimenting, learning organisations, and create a regional structural and institutional 'infrastructure' that corresponds to their cognitive, behavioural, and strategic aspects of learning". From a theoretical viewpoint, three major points can be made about localised learning policy. Policy should facilitate (1) both learning and unlearning, and (2) systemic and embedded learning. Furthermore, policy should (3) leave room for experimentation and variety.

Navarro (2003: 14) makes a more orthodox point in this vein arguing that government intervention should still be primarily focused on the proper functioning of markets, creating the favourable framework conditions for enterprise development and innovation. This is a call for ensuring appropriate regulatory frameworks are in place (as was called for in the mid-term review of the Lisbon Strategy), and implementing sound macroeconomic policies, ensuring availability of venture capital, promoting competition, etc.

In the context of globalisation and the relocation of traditional industries from higher cost to lower wage economies, this policy conclusion would indicate that although the unemployment and development implications of such restructuring might be ameliorated in developed countries, policy should not be directed towards propping up uncompetitive firms and industries in the long run.

### 5.4.4. Policy needs to be inclusive

A key policy question underlying the PILOT project was whether Europe should focus on high-technology or science-based industries in attempting to solve growth and employment problems, or whether it should look to the growth prospects within the industries on which the European economy is actually based: low-technology and medium-low-technology industries in manufacturing and services. An important PILOT result is that the policy issue is not a choice between these apparent alternatives.

The PILOT project showed that much of output and employment in modern economies is accounted for by both manufacturing and service LMT sectors. Such sectors are also significant users of the output from high-tech sectors. Therefore, in a modern economy, the levels of performance of both high-tech and non-high-tech sectors are heavily interdependent, and policy should view the economy as a whole. As a result, the promotion of the 90 percent of the economy that is not high-tech[12] also promotes the welfare of the high-tech sectors (Robertson and Patel 2006).

As a corollary, policies need to ensure that they encourage both the generation of knowledge and its diffusion, and that both operations are carried out at high velocity to maintain competitive advantage.

[12] This figure is based on the calculation by Nordhaus (2001) that slightly less than 10 per cent of manufacturing output in the USA in the late 1990s was in high-tech sectors. However, on this reading, the residual 90 per cent includes medium-high-tech sectors that are not part of PILOT's usage of "LMT". Nevertheless, as is illustrated in Figure 1 (Section 3.2.2, above), even using the narrower definition, substantially more than half of the European economy is accounted for by LMT sectors.

## IV. CONCLUSIONS AND POLICY IMPLICATIONS

### 1. Policy Implications and Recommendations

On the basis of our research findings it is possible to identify a number of significant factors and problem situations concerning innovation policy for LMT sectors.

#### 1.1. Limited awareness of LMT industries

Referring to the EU in general, our empirical findings show that there is little if any awareness of innovation-generating policies other than those focusing on R&D. Correspondingly, the low-tech sectors receive little attention from innovation policy makers on different levels, such as the EU, the national states and the regions. Therefore, a key policy task is to support activities and measures raising the awareness of low-tech industries and their specific needs and conditions. A fundamental precondition for this is the development of a new and broad understanding of innovation and the insight that one should no longer equate innovative ability with R&D activities alone. The more recent debate within the Commission and the OECD about the need for new R&D indicators certainly points in the right direction and should be intensified.

Such intensification might include the establishment by the EU of a mechanism to closely investigate the needs of LMT firms so as to identify ways of supporting innovativeness. Whatever means are identified to provide support must be flexible enough to correspond to the objective and cultural needs of the recipients. The problems of differences in Europe in the attitudes of entrepreneurs, which were especially prominent in the Polish case studies, underline why such institutional flexibility is essential.

PILOT research suggests that LMT firms from Poland and other new Member States may have an importance that extends beyond their immediate geographical contexts and across the EU as a whole. There is a need to examine this more closely and to research the potential for integrating the capabilities of Central and Eastern European firms into the dynamic of the Union, rather than *de facto* treating these companies as dinosaurs destined for extinction as a result of natural selection. A further fundamental prerequisite is a holistic view of industrial innovation processes and the relevant interlocking of different kinds of knowledge as well as of the different elements of the companies' capabilities which enable them to be innovative and profitable. The policy conclusion to be drawn would therefore be that it is necessary to focus on the industrial innovation chain as a whole, to concentrate more strongly on inter-sectoral connections and to make a point of finding the potentials of low-tech industries.

However, it must also be emphasised that the firms themselves have a low level awareness of innovation policies for LMT industries and that policy measures are perceived very differently by different firms. The policy measures that are regarded as helpful by some firms as a rule concern general aspects such as national policies on tax incentives and subsidies for various activities, and EU policies such as the Framework Programmes and Eureka. On the whole though, one can state that there are great innovation policy shortcomings as far as the specific problem situations of LMT companies are concerned.

### 1.2. The relevance of knowledge and company capabilities

As for the knowledge base, low-tech innovations presuppose the availability of specific practical in-house knowledge as well as the integration and use of complex knowledge inputs within networks. It is therefore an important policy task to conceive measures and to support activities which aim to improve the knowledge base and capabilities of low-tech companies. This task can be realised at both the level of EU-wide support programs and also at national and regional levels. In practice, such measures should be directed at promoting the different dimensions of, and particularly the preconditions for developing the capabilities of, LMT companies. The organisational conditions and management skills regarding a more efficient use of existing knowledge are especially in need of further development.

In this context a key problem relates to training and recruitment needs. The necessary training for the array of skills required by workers in the LMT companies is not readily available from mainstream providers. Standard qualifications do not provide the mix of skills that LMT firms require. Additionally, many of the firms are experiencing recruitment difficulties due either to the negative image of the industries or to skills shortages.

### 1.3. Local embeddedness and network relations

Policy tasks should focus on the development of the companies' organisational structures so that they are geared to the demands of cross-company co-operation with corresponding channels of communication, gateways and personnel responsibilities. In this respect, the professionalism of management of LMT firms should be supported and further developed. Another important policy task is to concentrate on improving the firms' capabilities for making the right strategic choice as regards the dilemma between globalisation and local embeddedness. The findings of the PILOT project show the importance of a balanced dynamic between global, local and regional policies that operate in all types of "environments" to which a firm may belong. The aim of policies at different levels to create infrastructure supporting the innovation process must facilitate this balanced dynamic. Clusters and fragmented economies need strong intermediate institutions and institutional infrastructure to provide appropriate local conditions. To set up such institutions, the positive combination of the vision of public bodies and the interests of the stakeholders (i.e. collective actors) are important factors.

### 1.4. Interrelationships of LMT with high-tech

A key policy question underlying the PILOT project was whether European innovation policy should focus on high-technology and science-based industries in attempting to solve growth and employment problems, or whether it should look to the growth prospects within the low-tech and medium-low-tech industries on which the European economy is actually based. An important PILOT result is a recognition that the policy issue is not a choice between these apparent alternatives.

The project showed that much of output and employment in modern economies is accounted for by both manufacturing and service LMT sectors. Such sectors are also significant users of the output from high-tech sectors. Therefore, in a modern economy, the levels of performance of both high-tech and non-high-tech sectors are heavily interdependent, and policy should view the economy as a whole. As a result, the promotion of the 90 percent of the economy (see note 13, above) that is not high-tech also promotes the welfare of the high-tech sectors (Robertson and Patel 2006).

Before formulating specific policies, however, the EU needs to establish a mechanism to closely investigate the needs of LMT firms and *the thought processes and aspirations of entrepreneurs and managers*. To judge from our studies, these issues are often not even on the radar screens of Commission bureaucrats and policies are often made *in vacuo* from an informational point of view. Moreover, institutions for delivering help need to be designed so that they correspond to the objective and cultural needs of the intended recipients. Policy makers need to inform themselves on the factors that managers feel to be important, rather than hypothesizing motivations, and target their recommendations to elicit positive responses given the psychological make-up of entrepreneurs and other managers. For example, there is considerable evidence that many owners of SMEs prize their independence and do not greatly value advice from governments. To deal with this, policy makers need to consult the views of what owners and managers regard as significant when launching institutions to improve innovation among LMT firms.

On this note, it has to be emphasised again that industrial innovations are for the most part not based on newly created scientific knowledge. Even where technical change is based on scientific activities, it is not necessarily based on recent ones; innovations stemming from the stock of knowledge and of the solution of practical problem of various types may be more important than the creation of new knowledge. Moreover, the relationship may be the other way around, with technology creating the foundation for scientific knowledge. LMT industries are well placed to play a decisive role in innovation because the contribution of LMT companies is frequently an important precondition both for the innovativeness of value chains – or production systems – and for the design, fabrication and use of a range of high-tech products. As is convincingly shown by Robertson and Patel (2006), the relationships between high-tech and non-high-tech sectors in developed economies are highly symbiotic and the well-being of high-tech firms and industries depends heavily on their ability to sell their outputs to other sectors in developed economies.

Collaboration and networking between companies of different industries at regional, national, and transnational levels are increasingly important determinants of the innovativeness and competitiveness of individual companies. These value chains, *filières* or clusters include low-tech companies, but not just as third tier participants in supply chains or as more or less passive recipients of technologically advanced machinery and equipment developed independently of user specifications. Furthermore, the dynamics and efficiency of value chains may crucially depend on the reliability and effectiveness, the capabilities and specific knowledge of their low-tech partners and on their integration into innovation processes in other firms in the cluster, whether low-tech or high-tech.

This focus on the contribution of low-tech industries to the innovativeness of industry as a whole is extremely important from a policy perspective, both at national and regional levels. It is indispensable for developing a proper foundation for the overall growth and performance possibilities of the European economy. Following the above line of argument, the high-tech prospects of many economies are based on the presence of and dynamic interaction with reliable low-tech functions and processes. The significance of low-tech companies as regards innovation policy must ultimately also be seen against the background of the strong and probably increasing international competitive pressure on complex technologies and products. Their market position can by no means be regarded as permanently stable and promising. High technologies and the corresponding know-how can, in the context of global economic integration, diffuse rapidly. And the crucial point is they are also quickly utilisable for innovations, so that the window for realising innovation profits in this sector is in many cases quite small. One instructive example, as experts stress, is that a developing country like China will in some years be one of the largest developers and producers of high-tech products such as mobile phones. Another example is the situation of the medium high-tech automotive industry in countries like Germany. It is occasionally pointed out that the dependence of German manufacturing on the auto industry provides specialisation advantages but that it also increases the risk of severe damage from competition as highly sophisticated cars are increasingly being produced more cheaply in newly industrialised countries (albeit often by German firms). The policy conclusion to be drawn would therefore be that it is necessary to focus on the industrial innovation chain as a whole, to concentrate more intensely on inter-sectoral connections and to make a point of identifying the potentials of low-tech industries. Most notably, the empirical findings show that there are favourable development potentials for LMT industries, not least in the high-tech-oriented countries of the EU.

## 2. Policy Relevance of the Project Results

The results in terms of policy were a basic objective of the PILOT project. We will focus here on two issues: results in terms of policy derived from the case studies; results in terms of policy derived from policies themselves.

### 2.1. Results in terms of policy derived from case studies

The results have been summarised and explained above. The main relevance of these results is in the extent to which they indicate an absence of clear focus in the promulgating and publicising of assistance for innovation. Most of the LMT firms in the PILOT study are unaware of policies that might assist them. Even where there is an awareness of the existence of policies, for example where there is awareness of funding for R&D, either this support is not appropriate for the firms or they do not perceive the appropriateness. Thus the firms in the PILOT project perceived themselves as in some sense excluded from R&D policies. This was indicated by explicit responses from some of the firms that there was a lack of interest in their industry, or that tax incentives and export subsidies were aimed at high-tech in particular, at the expense of other industries, or that R&D policies were focused on large companies rather than SMEs. It may be that among the problems in this context is a lack of absorptive capacity, in the sense that the spare capacity to understand the purposes of and to apply for the grants on offer is not available. This applies particularly to small firms where all resources are involved directly in production.

A second element in relation to the relevance of the case study results is that, as is the case in the literature on research and innovation, there is lack of clarity about the differences between radical and incremental innovation. The fact that many firms are not aware of the extent to which they themselves have introduced incremental innovations means that they are also unaware of the origins, and the supportive and facilitating factors, that have contributed to these innovations. Clearly a greater awareness of processes and drivers of this type of innovation would increase the likelihood of innovation.

Thirdly, while only a few of the LMT firms were successful in obtaining R&D grants, this nevertheless indicates that the same policies were often perceived in starkly different ways by firms that were in many respects similar, in the same industry, and sometimes even in the same country. Such less obvious factors as the uneven distribution of dynamic capabilities may explain some of these differences in perception.

### 2.2. Results in terms of policy derived from the policies themselves

From our examination of the local, regional, national and European policies, it is clear that there is, in general, very little implementation of policies that differentiate in any operational way between non-research based activities that lead to innovation and research based activities – in particular R&D – that lead to innovation. Even where there is an apparent process of clarification, where interactions between researchers on innovation and policy makers have led to the policy makers expressing awareness of such concepts as systems of innovation, there is little development and implementation of policies to enhance the reality behind the concept.

One aspect of this problem at the European level is the sharp administrative distinction between the Directorate General for Research and the Directorate General for Enterprise and Industry. Among the key aims of DG Research is "to develop the European Union's policy in the field of research and technological development and thereby contribute to the international competitiveness of European industry". Among the key aims of DG Enterprise and Industry is "to foster innovation both in the technical sphere as an adjunct to research, and in the business process". It is clear that these aims are closely related and that they would be more easily achieved through close collaboration among those designing and implementing policies to achieve them. However there is very little such collaboration between the two Directorate Generals. As a result, despite the obvious conceptual awareness of the policy makers, the policies implemented continue to be partial and narrow, and in general to ignore the systemic nature of the processes of innovation.

## 3. Future Research Needs

Further research is necessary on the origins, drivers and processes of non-research based innovation. It is necessary to improve our understanding of its cognitive and organisational preconditions and to develop schemes targeted at the improvement of innovation enabling capabilities of companies in low-tech and medium-low-tech industries that are the main sources of this kind of innovation.

Another important field of innovation research is the role of interrelationships between research-intensive, new and non-research-intensive, mature industries for the innovativeness of industry in general – that is, of both high-tech and low-tech sectors. Such research might lead to further, policy-specific research, aimed at identifying detailed ways in which policy might support non-research based innovation.

The need for research on the administrative structures within the EU, and on how the sharp distinctions within those structures between research and innovation might be bridged, is also indicated by the results of the project. Such research might also focus on the processes leading to the designing and implementing of research and innovation policies in general, and on ways of improving these processes.

Finally, it is a recommendation of PILOT that a unit focussing on non-research based innovation be established within the European Research Council. This implies ongoing research on the issues raised in PILOT.

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## VI. ANNEXES

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European Commission

**EUR 23152 — EU RESEARCH ON SOCIAL SCIENCES AND HUMANITIES — Policy and Innovation in Low-Tech — Knowledge Formation, Employment & Growth Contributions of the 'Old Economy' Industries in Europe - PILOT**

Luxembourg: Office for Official Publications of the European Communities

2007 — 108 pp. — 21,0 x 29,7 cm

ISBN 978-92-79-07781-4

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KI-NA-23152-EN-N

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ISBN 978-92-79-07781-4

9 789279 077814