"Low-Tech" Industries:
Innovativeness and Development Perspectives
A Summary of a European Research Project

PILOT Project Consortium

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Dortmund

December 2005

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The Project Results in a Nutshell

In the movement towards a knowledge society in the European Union (EU), 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 so-called high-tech, research-intensive and science-based industries as the key drivers of future economic prosperity. Such industries are seen 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, Low- and Medium-Low-Technologies (LMT) industries are deemed to offer severely limited prospects for future growth, and as a result, receive less explicit policy attention and support. A critique of this widely held view is the starting point of a EU funded research project with the acronym PILOT – "Policy and Innovation in Low-Tech: Knowledge Formation, Employment and Growth Contributions of the 'Old Economy' Industries in Europe". The following points provide a brief summary of the results of the project.

(1) The project found that most growth and employment in OECD countries still emanate from so-called LMT industries. Moreover, the firms in these industries are innovative and knowledge intensive without, by definition, engaging in R&D to any great extent, thus providing a striking challenge to the currently held notions about the sources of future industrial growth. 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.

(2) The micro examples of what goes on at the 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. It is clear that as an alternative to – or at least in addition to – R&D expenditures, analysts must use other indicators of innovativeness and

of the general level of technology in an economy. The PILOT 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 the use and construction of innovation indicators. In particular, PILOT research shows that the adoption of a family of indicators rather than a composite indicator is more appropriate.

(3) What are the preconditions for innovativeness in LMT companies? It can be argued that R&D in the established sense is only one and generally not the most important prerequisite for an organisation's innovativeness. Drawing on the discussion in the management sciences and economics on dynamic capabilities, a concept of innovation enabling capabilities is introduced. This concept aims at analysing the facilitating mechanisms and interdependencies between available resources and innovation results of diverse kinds; our analysis shows that LMT innovativeness is based on a particular enabling configuration of cognitive, financial and material (machinery etc.) resources that a company possesses.

(4) The project findings show that internal organisation practices - knowledge management and personnel policy - unquestionably play a vital role in this matter. 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. Additionally, network relations between companies and supportive social networks on a regional level are of great and growing importance as resources for firm capabilities. 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.

(5) 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. As the project findings show, interrelationships of low-tech and high-tech sectors are of major importance for the innovativeness of indus-

try in general. The so-called LMT 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.

(6) The policy recommendations of the project focus firstly on the specific situation of the newer member states of the EU. The project results show that the performance of these economies in general and of their LMT sectors in particular cannot be grasped without taking into account historical conditions, and especially without understanding the trauma of wartime destruction and the effects of nearly 50 years of communist policy concerning the economy, culture and morality. As the example of Poland shows, LMT industries raise many policy dilemmas. For the countries in the study in general, policy towards innovation in LMT industries can be improved; policy needs to be tailored; policy should conform to market processes; and policy needs to be broad-based.

(7) The research findings lead to a number of problems concerning innovation policy in the LMT sector. Several policy issues can 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 companies. Third, policy 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 promote the interrelationship between the sectors.

1. Challenges and Context of Research on Low- and Medium-Low-Technology (LMT) Industries

The main starting point of research on low-tech industries and the discussion on the development perspectives of such industries in the old industrialised countries of the European Union is a fundamental criticism of the widely held focus on high technology and necessitates a reexamination of the relevance of LMT sectors. To a large extent, this one-sided attention reflects the idea that ongoing societal change in modern societies can be characterised as typical of an emerging “Knowledge Society” (cf. Drucker, 1994; Stehr, 1994; Willke, 1998; David and Foray, 2003) or “Learning Economy” (cf. Lundvall and Borrás, 1997). These writers and others share the idea that modern organisations and societies are undergoing a fundamental change process, based on the enhanced significance of knowledge as a productive force and asset. Continual innovation, accompanied by a restructuring of work processes and organisation, is a decisive determinant of economic and social development, while the generation, diffusion and utilisation of knowledge is a core characteristic of firms and of economic activity as a whole.

To be sure, these discourses on the emerging knowledge society do describe important tendencies in economic and social development. We share the view that knowledge is an increasingly important resource, but we dispute much of the conventional wisdom about how the knowledge economy is structured and the implications for economic trends and hence policy measures. On the one hand, the knowledge economy is usually identified with a very small number of research-based or science-based activities, especially information and communications technologies (ICT), and biotechnology. On the other hand, it is often argued that as a consequence of increased knowledge intensity, the economies of industrialised countries in Europe and elsewhere are currently going through at least two great changes (Carson, 1998):

- A significant part of industrial production is relocating from its traditional sites to developing countries. The classic example is the exodus of textiles from the rich world over the past three decades. This applies particularly to labour-intensive ‘mature’ industries: quite soon, it is argued, many big Western firms in such industries will have more employees and even customers in developing countries than in developed ones.
- In many industrialised countries the balance of economic activity is swinging from manufacturing to services. Even in Germany and Japan, which rebuilt so many factories after 1945, manufacturing’s general share of jobs in relation to the whole economy is declining rapidly in favour of high-tech manufacturing and services.

Particularly in Western countries, those focusing on these trends have been involved in a debate about an ongoing process of “de-industrialisation”, originating in the 1970s (cf. Fröbel et al., 1977). By the end of the 1980s, many American and European experts had come to believe that their countries’ industries were being “hollowed out” as many basic production activities relocated to other areas.

The policy consequence drawn from this development is the well-known objective of making the EU the world’s most competitive knowledge-based economy. How this objective can be reached has been debated since then, with the policy makers focusing especially on an important target indicator selected to reflect the objective, namely that the EU should achieve a R&D to GDP ratio of three percent. This political and economic objective has been strongly identified with the promotion of high-tech, high-R&D industries.

These arguments are interlinked with a well-known indicator measuring the ratio of R&D expenditure to turnover for a company or a business sector (OECD, 2002). According to the OECD categories, the industrial sectors can be classified as follows (Table 1):

Table 1: OECD classification of technology intensity

High-Tech industries	R&D/Turnover > 5%
Medium-High-Tech industries	5% > R&D/Turnover > 3%
Medium-Low-Tech industries	3% > R&D/Turnover > 0.9%
Low-Tech industries	0.9% > R&D/Turnover > 0%

High-technology sectors (“high-tech”) are those with a R&D intensity or more than 5 percent and sectors with complex technology (“medium-high-tech”) with a R&D intensity between 3 percent and 5 percent. Industries which are not research-intensive (“medium-low-tech” and “low-tech”) have a R&D intensity below 3 percent and are here referred to together as *low-tech and medium-low-tech (LMT).* Pharmaceuticals, the electronics industry, motor vehicles, the aerospace industry as well as mechanical engineering, for instance, are categorised as high-tech or medium-high-tech. On the other hand, the LMT category includes “more mature” industries such as the manufacture of household appliances, the food industry, the paper, publishing and print industry, the wood and furniture industry and the manufacture of metal products – such as the foundry industry – as well as the manufacture of plastic products (Table 2).

Table 2: OECD classification of manufacturing industries by technological intensity

R&D intensity[1] for aggregate of 12 OECD countries[2]

	1991	1995	1999
High-technology industries	**9.4**	**9.2**	**8.7**
Aircraft and spacecraft	13.9	16.2	10.3
Pharmaceuticals	9.4	10.6	10.5
Office, accounting and computing machinery	10.9	7.5	7.2
Radio, TV and communications equipment	7.9	7.7	7.4
Medical, precision and optical instruments	6.6	7.7	9.7
Medium-high-technology industries	**3.1**	**2.9**	**3.0**
Electrical machinery and apparatus, n.e.c.	4.2	4.0	3.6
Motor vehicles, trailers and semi-trailers	3.7	3.5	3.5
Chemicals excluding pharmaceuticals	3.4	2.8	2.9
Railroad equipment and transport equipment , n.e.c.	2.9	2.6	3.1
Machinery and equipment, n.e.c.	1.9	2.0	2.2
Medium-low-technology industries	**0.9**	**0.8**	**0.7**
Building and repairing of ships and boats	0.9	0.9	1.0
Rubber and plastics products	1.0	0.8	1.0
Coke, refined petroleum products and nuclear fuel	1.2	0.9	0.4
Other non-metallic mineral products	1.0	0.8	0.8
Basic metals and fabricated metal products	0.7	0.6	0.6
Low-technology industries	**0.3**	**0.3**	**0.4**
Manufacturing, n.e.c.; Recycling	0.5	0.4	0.5
Wood, pulp, paper, paper products, printing and publishing	0.3	0.3	0.4
Food products, beverages, and tobacco	0.3	0.3	0.3
Textiles, textile products, leather and footwear	0.2	0.3	0.3
Total manufacturing	**2.5**	**2.4**	**2.6**

Source: OECD: ANBERD and STAN databases, May 2003

[1]R&D intensity defined as direct R&D expenditures as a percentage of production (gross output), calculated after converting countries' R&D expenditures and production using GDP PPPs
[2]United States, Canada, Japan, Denmark, Finland, France, Germany, Ireland, Italy, Spain, Sweden, United Kingdom

Source: OECD Science, Technology and Industry Scoreboard 2005, Annex A, p. 183, OECD 2005 (modified)

In this debate, the fact that all industrialised countries have a large proportion of LMT industries, and the fact that these industries (whatever their vintage) provide goods and services that are absolutely vital to the function of modern societies (cf. section 3) are often simply ignored. In spite of growing global competition, particularly in the sectors of traditional and mature industries, this continues to hold true for the industrialised countries of Western Europe as well as for the transition economies of Middle and Eastern Europe.

Further evidence for the importance of the LMT sector is provided by a number of empirical findings which emphasise the innovation ability of the low-tech sector particularly in high-tech countries (e.g. Maskell, 1998; Palmberg, 2001; Tunzelmann and Acha, 2005). Thus *The Economist*, for instance, referred to "the strange life" of low-tech industries in high-tech California (*The Economist*, 1998). From the perspective of economic history, one can argue that low-tech industries were among the pioneers of multi-divisional modes of organising the production and distribution of a continuous flow of branded goods. Hence, we agree with Mendonça and von Tunzelmann (2004, 15) that, "Innovation in low-tech industries should … not be seen as a contradiction in terms."

The questions which pose themselves are therefore:

- What are the reasons for the remarkable stability of LMT in the industrialised countries?
- Can LMT sectors be called innovative and is there a specific mode of innovativeness of non-science based companies?
- What policy recommendation for the promotion of LMT can be derived from the factual record and sound analysis?

These are the basic questions of the research project entitled "Policy and Innovation in Low-Tech: Knowledge Formation, Employment & Growth Contributions of the 'Old Economy' Industries in Europe" (PILOT), which was undertaken by a consortium of social scientists from eleven universities and research institutes in nine European countries. PILOT began in December 2002 and ran until the end of 2005.[1]

2. Research Objectives and Methodology

PILOT's research on LMT industries has aimed at deepening the understanding of the growing knowledge intensity characterising economic and social development in Europe. A central assumption was that this process does not depend exclusively on industries with frontline technological knowledge but also on LMT industries. *The hypothesis is that these are not necessarily low-growth industries; many companies and branches within these industries are growing fast in comparison to the rest of the economy, are interlinked with high-tech and service branches, and provide an important ba-*

[1] The PILOT project was financed within Framework Programme 5, Key Action "Improving the Socio-economic Knowledge Base" (HPSE-CT-2002-00112). The project was coordinated by the Chair of Economic and Industrial Sociology of the University of Dortmund (is@wiso.uni-dortmund.de). The duration of the project was from December 2002 to November 2005. For more information see: www.pilot-project.org. The project is also discussed in more detail in Hirsch-Kreinsen et al. (2005). The main findings are presented in Bender et al. 2005 (forthcoming).

sis for future growth and employment. The role and importance of these industries in different European nations and for the economic and social prospects of Europe as a whole have been analysed by the project consortium.

The research objectives of the project were:

- To determine the role and importance of specific LMT sectors in the context of economic development in general.
- To identify the organisational and societal preconditions and mechanisms that enable innovation and knowledge creation in LMT industries.
- To ascertain the relevance of firm-level knowledge from a network perspective in order to gain an understanding of innovative ability along whole value-chains, including high-tech and service companies.
- To contribute to the formulation of policies on industrial restructuring which pay appropriate attention to the significance of LMT industries for the further economic and social development of Europe.

To achieve these project objectives and tasks, we have used a mix of different statistical and case study-oriented methodologies. On the one hand, conceptual, taxonomic and statistical data issues have been tackled, while on the other, low-tech firms have been scrutinised empirically. The core of the project was the generation of an extensive series of 43 company case studies in eleven countries across Europe.

Box 1: Methodological Background

The sample consists of companies of all the relevant PILOT economic sectors and thus covers the wide range of different economic sub-sectors in which low-tech companies are active. The sample also corresponds to the diversity of LMT sectors in terms of many other factors including turnover, ownership, value chain position, batch sizes, etc.. The bulk of the companies investigated were small- and medium-size enterprises with between 50 and 500 workers (Table 3).

Each project partner conducted four case studies in two different industrial branches. One branch – the metal sector – was pre-selected and the same for all partners, while the other branch was chosen individually by the partners according to their own national or regional backgrounds in terms of growth or employment.

Apart from visits to the company sites, the case studies consisted mainly of several interviews with representatives of the chosen companies, e.g. managing directors, departmental managers for production, personnel and/or R&D, shop floor personnel, works councils etc.

A standardised questionnaire was used to collect basic data on each 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 extensive interviews for each case study (based on a master guideline common to all na-

tional project teams) with company representatives on different levels and with different functions, by site inspections and by an analysis of the firms' publicly available documents. The case studies were conducted over the period spring 2003-summer 2004.

Table 3: The PILOT case studies

Number of employees	Industrial sectors				
	Paper & Pulp	Textile	Food	Wood & Furniture	Metal
1 – 50		1	1	1	5
51 – 100	3	1	2	2	6
101 – 250	1		1		6
251 – 500		1	1	1	5
> 500	1		1		3
Sum (N=43)	5	3	6	4	25

3. The "Strange Life" of LMT

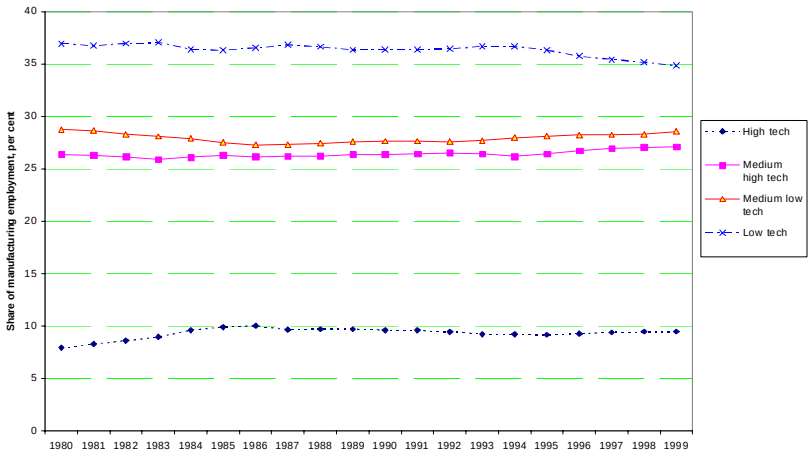
Generally, and not surprisingly, the statistical data show the well- known picture of economic development in all mature industrial countries (for more details cf. Kaloudis et al. 2005). The following empirical findings should be stressed:

There is a clear and well-known trend for industry's share of total employment to decrease rapidly and for that of the service sector to increase just as – if not more – rapidly. In the period 1981-1999 the share of services in employment grew strongly, from 60.7% to 70.5% of total employment in 15 OECD countries. The largest shares of growth in services occurred in two broad areas: financial services, and community and social services (the latter including such activities as health care and education). During the same period, manufacturing employment declined from 21.8% to 16.7% of total employment.

However, if one examines the industrial sector more closely, some surprising findings arise with regard to the significance of the LMT sectors. The data show that the LMT industries play a very important role in employment in all industrialised countries (Figure 1). LMT industries account, roughly speaking, for over 60 percent of employment in the whole manufacturing sector whereas the share of high-tech industries is less than 10 percent. There has been a tendency for the low-tech industries' share of manufacturing to decline during the long period 1980-1999, while the share of high-tech industries has increased. A similar trend can be observed regarding the share of value added of the different sectors in manufacturing. In the long run, starting from a low level, high-tech

sectors show a rising share of the value added in manufacturing while the share of the LMT sectors is declining. However, these declines are not marked, and the LMT industries still constitute by far the largest part of the manufacturing sector in OECD economies. It is debatable whether there is a real structural change in the period examined here. In fact, the low-tech sectors continue to evince remarkable stability and a high share of employment.

Figure 1: Shares of employment in total manufacturing. 1980-1999. 11 OECD countries combined[2]



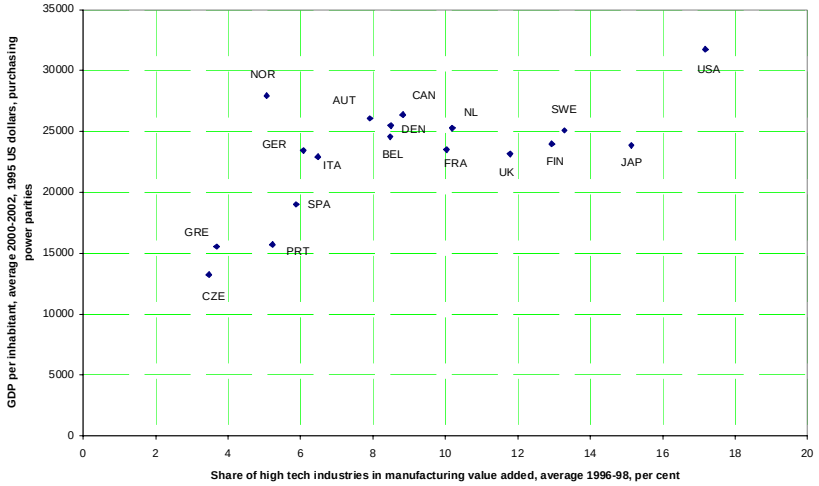
Source: Kaloudis et al. (2005)

In addition, there is no clear connection between high technology intensity and national growth rates. The question is whether countries with a higher share of high-tech sectors have the best growth performance. On the basis of the statistical data no positive correlation can be found between the high tech share in manufacturing value added and the rate of growth of GDP per inhabitant. This is illustrated in Figure 2.

Furthermore, it cannot be generally concluded that only high-tech countries are also high growth countries. Rather, it can be shown that many low-tech countries have a significant growth performance. All our findings lead again to the question: What are the reasons for this remarkable stability of LMT industries? The answer requires a discussion on the mode of innovation in non-science based industries.

[2] The figure is based on the OECD's STAN database, which comprises data at 2 and 3 ISIC digit levels for the manufacturing sectors of OECD economies. Data are shown only for those OECD countries for which sufficient data are available: Austria, Denmark, Finland, France, Italy, Japan, Norway, Portugal, Spain, Sweden and USA. The two most important countries which are excluded during this first period 1980-1991, on account of insufficient data, Germany and the UK, are included in the second period covering the years 1991-2002 (Kaloudis et al., 2005).

Figure 2: GDP per capita. Average 2000-2002, 1995 US dollars (y-axis); share of high tech industries in manufacturing value added. Average 1996-1998 (x-axis)



Source: Kaloudis et al. (2005)

Box 2: A general conclusion concerning the economic relevance of LMT

In the words of Kaloudis et al. (2005): "There is no evidence supporting the argument that the high tech economies are also the high growth economies. This suggests that different economies can follow different paths of economic growth. Countries play different roles in the differentiated international economic system with clear patterns of division of labour among the highly developed economies.

Based on these conclusions we would hypothesize that growth is not primarily rooted in the creation of new sectors but in the internal transformation of sectors which already exist and/or are growing, such as, the service sector. Overemphasising the role of the high tech sectors as isolated contributors to growth ignores this major dimension of change due to transformation in advanced economies.

Such oversimplifications in the conventional wisdom are rooted in fundamental assumptions supporting modern research and innovation policies, which by overemphasising the role of R&D in economic growth often underestimate processes of change and the needs of those sectors of the economy with low R&D-investments."

4. Mode of Innovation

A central precondition for the surprising stability of the LMT industries is their strategic flexibility and ability to innovate. These enable them to face up to the pressures of world market competition by developing new products, new process technologies and new ways of organising. For a better comprehension of this connection, it is essential to come to an understanding of innovation processes that a narrow focus on R&D intensity

obscures. In order to deal with this issue, PILOT has focused on the central dimensions and mechanisms that underlie the innovation ability of firms in LMT sectors.

4.1 Basic Dimensions

The starting point of our analysis is the argument that the dominant concepts developed so far to describe and analyse industrial and technological change have many shortcomings. The main argument in this respect is criticism of the interpretation of innovation processes as a linear model. This linear model assumes that research and development activities are the starting point of any kind of innovation and that scientifically generated knowledge is a prerequisite for the development of new technologies. If firms with low or no R&D – i.e. most LMT firms – are innovative, then the linear model should not be accepted as the basis for debates on innovations. A more theoretically based criticism refers to Joseph Schumpeter's concept of innovation (cf. Laestadius et al., 2005). This concept establishes no compelling connection between innovation and scientific or technological originality at all. All creative activities which contribute to diversity and thus generate profits count as innovations in Schumpeter's concept. Many of the problems faced by today's innovation researchers, such as classifying the "uniqueness" or "technology height" of innovations, are of little relevance from this perspective. What matters is not the existence of a science base but professional creativity that can score in the marketplace. Schumpeter's formulations allow for a better understanding of the creative processes which take place in so-called low-tech manufacturing sectors as well as in many service sectors, including those labelled knowledge intensive business services.

Following this basic idea, an analysis of LMT innovation processes may start by asking how successful companies manage to develop or create the capabilities and competencies which make them perform better than their competitors or at least help them to survive commercially. Part of the answer may, of course, be found in R&D activities or in what can be identified as R&D, carried out and financed in-house or acquired from outside sources. Another part may be related to other activities, of which some may be called innovations and others may be a far cry from what innovation researchers normally focus on. A convincing analysis has to identify and capture all these "profit enhancing" or "survival facilitating" activities irrespective of their labelling. To analyse the requirements and preconditions for the innovativeness of low-tech companies more closely, it is therefore necessary to clarify the specific structural conditions of these firms. These can be characterised relatively precisely by recourse to the R&D intensity indicator: The companies have limited or no independent R&D capacities at all and their in-house expenditures on, for example, R&D personnel and other costs and investments connected with R&D activities are low. Their outside spending on R&D by other companies or organisations is likewise small. As a result, one can assume that these

firms have other kinds of resources and capacities to act, on which their innovation ability is based and which (functionally) compensate for their lack of R&D capacity (Palmberg 2001).

Box 3: Towards an alternative system for classification of innovativeness

Laestadius, et al. (2005) emphasise that at least five dimensions should be considered when analysing the innovativeness of LMT firms: "So far we argue that all firms in all industries may be analyzed in five dimensions which can be measured through quantitative data collection and/or surveys. We may thus classify firms according to their:

- R&D intensity
- Design intensity
- Technological intensity
- Skill intensity (Human capital orientation)
- Innovation intensity

So, this will end up with five indicators – or six if adding an organizational one – which together make up a profile for the individual firm and/or for an aggregate of firms, e.g. an industry or a "sector" aggregate of different industries (e.g. the "ICT-sector" or the "technological system for pulp and paper"). These indicators 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 … narrower 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 the D of R&D. 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 innovation intensity and thus have some impact on the further revisions of the Oslo Manual."

4.2 Capabilities

A possible starting point for such an analysis could be resource-oriented analysis concepts of innovation and management research (e.g. Penrose, 1959; Foss, 1997) which lend themselves well to attempts to specify the above-mentioned connections. These concepts aim at examining how firms attain competitive and innovative advantages, what resources they have at their disposal in this respect and how they employ these resources. The central argument is that companies can be characterised by means of their specific combination of more or less special and rare resources, especially of knowledge in miscellaneous forms and not only of R&D based scientific knowledge. Furthermore they must apply a specific competency to be able to make use of these resources for their strategic goals in each case. The capability approach of Teece et al. (Teece and Pisano, 1994; Teece, Pisano and Shuen, 1997) elaborated more recently by Zollo and Winter (2002), is relevant in this context because it provides a framework for examining the broad variety of firm-specific factors that are important for explaining

innovations. Design and synthesising capabilities can be regarded as especially significant in this respect.

To be able to analyse these connections and the mechanisms linking available resources and innovation outcomes of diverse kinds more precisely, a specification of the capability approach is needed. Bender and Laestadius (2005) provide this by suggest that the term capabilities should not be understood as a pattern of activities but rather as a term to address specific preconditions for specific activities: a particular configuration for enabling the cognitive, financial and material (machinery etc.) resources that an organisation possesses. They further suggest two fundamental dimensions, namely transformative and configurational capabilities. The former focuses on the enduring ability of an organisation to transform externally available, codified knowledge into company-specific knowledge, the latter on the enduring ability to synthesise novelty by creating new configurations of knowledge, artefacts and actors. Three specific aspects of configurational capabilities are described:

- *cognitive*: configuring distributed knowledge of different kinds;
- *organisational*: configuring distributed actors and other repositories of knowledge and know-how;
- *design*: configuring functional features and solutions.

The distinction between transformative and configurational capabilities is analytical; empirically the two dimensions are tightly interwoven.

Given the types of companies which were examined, the analysis of the empirical results on the basis of these categories yields no surprising findings. Innovation in this sense is to a great extent the result of the transformation and reconfiguration of well-known internal and external knowledge and of components and technologies developed elsewhere. What all the case firms in this sample had in common was that not one of them based their innovativeness on recent scientific findings and knowledge. The conclusion of this analysis is that even within mature industries with unfavourable cost conditions at least some firms may develop capabilities which make them profitable and competitive over a relatively long period. In these cases, innovation is to a great extent the result of processes of transforming and configuring generally well known knowledge, components and technologies developed elsewhere. There may also be knowledge formation processes similar to what can be found in other firms labelled as high-tech or medium high-tech. In general, this approach to “innovation enabling capabilities” developed in the context of the PILOT project is not only appropriate for the analysis of innovation processes in LMT industries but may also be useful for science-based innovations.

Box 4: An example of an innovative LMT company

Bender and Laestadius (2005) describe an example of a specific aspect of configurational capabilities: “We have seen many examples of creative configuring of distributed knowledge and competence in the case studies. One of them is an Austrian producer of rails. Their capabilities to join forces with external expertise in order to foster development of innovative product solutions are a critical success factor. It is important to note that we are not talking about just the competence to organise external support for continuous improvements of their core products. This is something one can reasonably expect from any competitive producer. The competitive edge results from the ability to be more creative when needed. In this specific case the company is confronted with a general trend in the railway industries. Due in part to structural changes on the side of many railway transportation companies (liberalisation, segmentation into independent functional units etc.) the customers tend to ask for system solutions rather than simply for tracks. In such a situation suppliers have to be able to functionally augment their core products without giving up the advantages of specialisation. The firm discussed here is well known for being able to produce the worldwide longest head hardened non-welded pieces of rail (120 metres). This is in itself an innovation. But they also offer a novel process to lay these bulky pieces. The appropriate handling system was developed in collaboration with a German manufacturer of railway equipment and machinery; its design embodies the merged expertise of both partners.”

5. Practices and Resources

5.1 Knowledge Management and Personnel Policy

The concept of capabilities refers to the conditions on which an enterprise’s ability to be innovative depends. This question can be answered by looking at the findings of innovation studies. According to these, one can basically start from the assumption that this ability is strongly embedded in the practices and processes of the firm’s organisation (cf. Henderson and Clark 1990). Following Schmierl and Köhler (2005), these include the modes of knowledge management and personnel policy used by a firm as central elements of transformative capabilities in LMT companies. According to the case studies findings, there is neither one common pattern regarding work-force and work organisation nor one shared pattern of knowledge creation and utilisation. The knowledge base of the low-tech companies investigated can be characterised as “accumulated internal knowledge”. Regarding the processes of knowledge creation, two main, opposing, patterns were identified:

- The stimulation of collective accumulated knowledge on the shop-floor, and
- The concentration of knowledge creation in the hands of specialised personnel in the planning departments in terms of a Taylorist tradition of work design.

Both patterns are characterised by a systematic combination of dispersed knowledge and an incorporation and assimilation of external knowledge. It can be shown that LMT firms are not basic innovators but combine existing codified knowledge with practical knowledge in a competitive way. The knowledge management strategies which can be identified are not at all different from other sectors although there was one frequently expressed position: “We are followers, not trendsetters”. LMT firms very often improve their capability to incorporate external knowledge which has already been implemented and tried by others. Benchmarking and learning from the best is a very common practice which requires the capability to observe, to obtain information, to analyse and to transform machines, design or organisational structures from other contexts.

As regards work organisation and personnel policy, many low-tech companies are characterised by specific capabilities in processing technology and logistics which produce uniqueness and competitiveness. The case study sample ranges from companies using ultra-modern machinery and highly automated processes (especially in the paper industry, but also in parts of the metal-working industry) to companies which are barely automated and still largely depend on traditional manual labour and standard technology (as in the food, textile and wood processing industries). However, as a general rule, it can be emphasised that the term low-tech as a classification of sectors is not necessarily synonymous with low-tech manufacturing processes.

The same holds true for patterns of work organisation:

- The workforce and work organisation vary from company to company. This means that there is definitely no low-tech specific pattern of work organisation and qualification levels which is systematically distinct from medium or high-tech sectors. This heterogeneous economic segment is indeed characterised by a variety of different forms of work organisation.
- The concrete work organisation is determined by an interplay of many factors, such as product complexity, production process characteristics and automation, personnel policy, quality requirements and customer demands. There is also a wide variety of qualifications and skills with differences as to where and in what form transformative capabilities are located internally.
- Most firms, however, are characterised by the concentration of strategic knowledge in the hands of a rather small group of managers and technical staff while the production workers are more or less skilled operatives.

The dominant patterns of personnel policy rely heavily on the predominance of internal training, which is mostly supplied unsystematically during daily work and at the workplace. In most cases there are forms of vocational further training predominant with a

great range of intensities. Apart from characteristic differences (e.g. between the sectors or certain types of enterprises). Schmierl and Köhler (2005) found three predominant basic modes of vocational education and training in the sample. In order of importance, these are:

- Internal training on the job and learning by doing;
- Recruitment of key workers on the external labour market followed by an internal phase of training on the job; and
- Cooperative further training with other institutions and companies.

To summarise the PILOT findings with respect to knowledge management and personnel policy in the investigated low-tech companies, it can be stated that the regular workforces of many companies hold a considerable, as yet underdeveloped, potential for the improvement of transformative capabilities which can be tapped by strategic training and by improved and appropriate forms of work organisation. As the authors emphasise, most of the investigated low-tech companies seem to follow a policy of "muddling through" instead of a systematic and foresighted personnel policy.

Box 5: An Example for a Systematic and Foresighted Personnel Policy in LMT

Schmierl and Köhler (2005) suggest that a German paper mill with approximately 100 employees may stand as a prototype for an advanced personnel policy including an integrated work organisation, technology and workforce related strategy. Within the process the paper-machine plays a central role. Modern ones are up to 140 metres long, up to 25 metres high and can produce 1900 m/minute of paper. Hence the key challenge in this industry is to adapt all other productive factors hierarchically to the paper-machine.

The company's business strategy is characterised by a very modern and innovative work organisation, including maintenance. The huge paper machine is operated in a five shift system, each shift consisting of 14 workers, who run the whole production line. Each shift can be further differentiated into four teams of three workers and one team of two, with each team responsible for a specific segment of the paper machine. The different shifts and teams operate – in contrast to the usual very hierarchical work organisation in the paper industry – relatively autonomously and are individually accountable.

For example the change of the shifts is organised by the respective shift personnel themselves. The workers in a team have different, distinct qualifications. In general one is a paper-maker, one is an electrician and one is a mechanic. Such hybrid team qualifications are necessary, as the teams have to fulfil an extraordinarily wide range of tasks and activities. Remarkably, each shift is not only responsible for the running and operating of the machine, but also for its maintenance. The degree of reliance on the knowledge of the workers is reflected in the fact that only skilled workers are employed.

The model of integrative maintenance requires hybrid qualifications – within the entire workforce and even within the single work teams. Furthermore, through the teams

a continuous transfer of knowledge is enabled. A system of reciprocal training-on-the-job prevails, in the sense that the mechanics, for example, train the paper makers regarding the maintenance of the machines, while the paper makers in turn impart their paper-specific knowledge to their colleagues. Finally, the relevance of this internal source of knowledge is reflected in the efforts the management undertakes to promote learning processes.

For example a specific collective agreement regarding the working time was implemented at the plant. Whereas the weekly working time in the paper industry is usually 38 hours, this firm's workers of the company must put in 39 hours. In the additional hour they are obliged to take part in on-the-job training, e.g. to learn to operate on different sections of the paper machine. It is striking that the concrete nature of this training is not determined by the management. The complete training – even the timing – is organised autonomously by the employees. Only its content is agreed with superiors according to production necessities and the company's business strategy.

5.2 Networks and Local Embeddedness

Network relations between companies and supportive social networks are also of great and growing importance as resources for the companies' capabilities. 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. This is the basic argument of Garibaldo and Jacobson (2005), whose systematic analysis of the empirical findings concludes that:

- The equation "low-medium- tech industry = locally embedded processes" is not tenable; while some of the businesses studied are highly embedded, others are not.
- Likewise, the equation "low-medium-tech = structural weakness in the face of globalisation" is wrong; some of the study cases provide evidence of strongly embedded processes but nonetheless proved able to attain a global market position.

Many of the cases investigated concur with overall business trends towards increasing internationalisation. For many LMT firms, an increase in internationalisation has meant a decrease in territorial embeddedness. What is significant, though, is that a number of the firms have successfully increased their level of globalisation while simultaneously maintaining a high degree of local embeddedness. In these cases, the research findings substantiate the connections well-known from earlier regional research – that firms in general, but especially LMT firms, are very sensitive to the density of the institutional set-up both on the national and sub-national levels. "Density" in this case stands for a mix of physically available infrastructures, of educational and vocational knowledge creation, and of diffusion and brokerage facilities. Thus there is no typical LMT firm characterised by standard behaviour concerning global or local orientation strategies. On the contrary, there are close interdependencies between these factors.

Box 6: The Dilemma between Globalisation and Territorial Orientation

As Garibaldo and Jacobson (2005) sum up their findings, the success of LMT firms can depend on contradictory strategies: "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. 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 utilize the embedded factor to shape a specific product/service asset in the global scene while at the same time to disembed the standardised products/services. This results in activities competitively done in – and unique to – a location remaining there, while others are moved to where they can be done more cheaply. 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 quality – for instance quality or delivery reliability – with a country or a region. In this case, too, the strategy is not simple because it cannot be the mere continuation of the tradition; the same "content" should be made available according to new standards."

In this context, the aspect of the integration of LMT firms into value chains is also of importance. Especially in the light of a progressive restructuring process of value chains, the question of where LMT firms position themselves is of strategic importance. The empirical findings show that LMT firms are distributed at different levels so that there is no single formula for success. Box 7 discusses the importance of a firm's location in a value chain and outlines ways of increasing integration.

LMT companies often play a strategic role in the smooth functioning of value chains. It is not surprising that proximity plays an important role in this regard. However, this need not necessarily mean spatial proximity. More important are cultural and organisational proximity that constitute the precondition for the passing on of knowledge (especially practical, non-codified knowledge) between companies. Again the social context is of critical importance for technological evolution and innovative capacity. In many cases, value chains as well as clusters need strong intermediate institutions and institutional infrastructures to provide resources for the management and organisation of networks. Such institutions can be created through the combined efforts of public institutions and local stakeholders so that social contexts can be generated that strengthen the innovation process. Where LMT firms are otherwise excluded from innovative networks, this process can lead to their inclusion.

Box 7: How to integrate LMT companies into global value chains

"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 is a matter of survival; moving up means acquiring the capability (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 – depending on their actual positioning along the value chain - our LMT firms have a low level of integration. 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 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" (Garibaldo and Jacobson, 2005).

5.3 Interrelationships of LMT with High-Tech Sectors

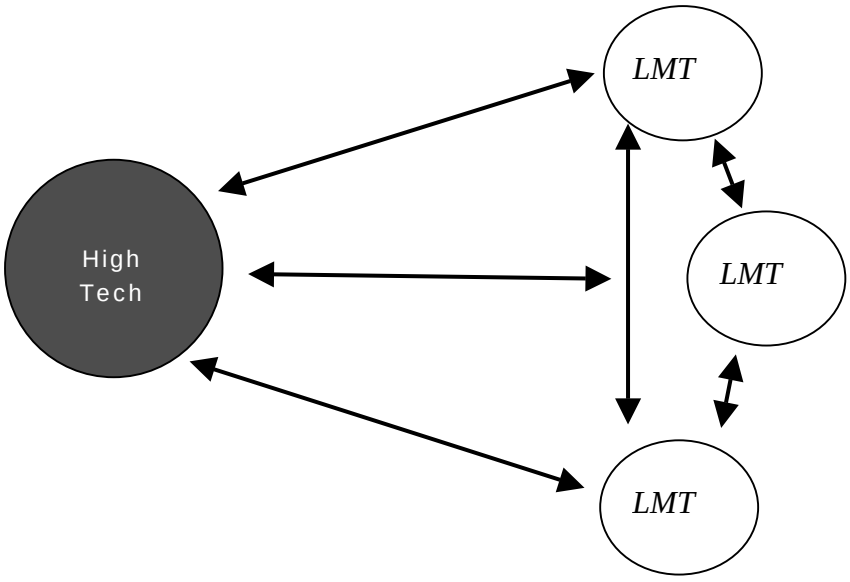
As shown above, the term low-tech as a classification of sectors is not necessarily synonymous with low-tech manufacturing processes. Therefore both the ability to integrate and to utilize high-tech manufacturing technologies and the relationship of low-tech to high-tech sectors are of decisive importance for the development perspectives and prospects of LMT companies.

However, as the PILOT findings show, technological flows do not move only from new and higher-technology sectors to older and lower-technology sectors. The analysis of the interrelationships between LMT companies and high-tech companies within value chains clearly show the strategic role LMT companies play for innovation in high-tech (cf. Bardi et al. 2005). In different cases it could be recognised that LMT companies actually boost the innovative capabilities of high-tech firms. In the case of the paper industry in Germany the main impulse for innovation typically comes from the paper manufacturer's request that the chemical supplier, a high-tech company, should either alter an already existing product or develop a new one (e.g. a new dye). The fostering of innovation in high-tech companies by LMT firms is also illustrated by an Italian case on the

value chain for sintering. In this case a die manufacturer, which is formally defined as a low-tech company, is involved in continual product innovation and is able to influence the design processes of its high-tech clients.

Furthermore, Robertson and Patel (2005) emphasise that in many cases the viability of high-tech sectors and the levels of resources devoted to research and development are directly related to the rate of diffusion because the main customers for high-tech products are in the LMT sectors, and therefore the rates of return to R&D in high-tech areas are a direct function of rates of technological diffusion. For Robertson and Patel (2005) "perhaps the most important backward linkage from LMT to high-tech industries comes simply from the revenue that sales provide, which helps to cover the substantial fixed costs that arise out of the innovation process and engenders economies of scale. In innovative situations, lumpiness and resulting non-convexities affect several areas including gearing up for production and the expenses associated with R&D itself. Diffusion can be crucial at this stage because the larger the number of LMT industries that adopt an innovation, the quicker the rate of amortisation of development costs will be. These economies of scale can then be translated into lower prices of innovative products for the LMT industries (greater pecuniary externalities), further economies of scale for the high-technology industries, and the generation of what Nurske (1953) has termed a 'beneficent circle'". This relationship between high- and low-tech industries is depicted in Figure 3.

Figure 3: Reciprocal Relationships between High Technology Sectors and Other Sectors



Source: Robertson and Patel 2005

The project findings emphasise that future industrial development in Europe does not depend on making a choice between high-tech and LMT industries. Rather, the performance of all these sectors is inextricably linked. On the one hand the productivity of LMT sectors is based on high-tech innovations, but on the other, the innovative capability of the high-tech sectors depends on their narrow relationship with LMT industries.

6. The Specific Situation of a New EU Member State: Poland

The conditions and patterns of innovations in LMT sectors outlined above mostly relate to Western and Northern European countries with their generations-long free market experiences. It is obvious that the economic and industrial situation in the new Central European Member States is structurally different from that of the Western states. In the context of the PILOT project, this was exemplified by the situation of Poland. The situation of the low-tech sector in Poland is not comparable to that of the corresponding sector in the Western EU countries.

In their analysis, Borkowski and Marcinkowski (2005) refer to the agrarian past of the majority of Central and East European societies, their limited industrial traditions, the strong impact of so-called socialist industrialisation, years of communist rule and finally the transformation process and the new imperatives of the market economy. Their conclusion is that all of this resulted in a lower level of innovativeness in the LMT sectors and in the country's economy as a whole. And they continue: "There is a difference between LMT firms of the East and the West which is a result, first of all, of the backwardness of their social, cultural, legal, capital and institutional environment which is firstly due to differences formed over time (historical determinants), and secondly due to the separation of these countries, with the consent of the Allies, from Western civilisation , and especially from its work ethos, culture, learning and the democratic system of government (political determinants)." As described by them in more detail, these determinants are reflected in the organisational culture of the enterprises as well as in the institutional and economic environment.

For instance, the fact that currently approximately 70 percent of the banking system in Poland is in Western ownership can be regarded as a decisive factor in the specific Polish situation.

- On the one hand, this takeover led to the modernisation of the financial system and the surprisingly rapid introduction of methods, techniques and financial tools previously unknown in Poland.

- On the other hand, such a situation holds certain threats. Banks are a decisive precondition for the economic development of the country in which they are based.

The latter has led to a well-founded apprehension about loss of access to necessary investment capital. Indeed, it is well documented that firms competing with their counterparts in the countries in which the banks have their headquarters may encounter problems in obtaining loans. This has already taken place in Poland and has also been connected to the purchase and later with the closing of competitive plants.

At the same time, however, it is obvious that the economic situation in Poland – contrary to the situation in other new Member States – is characterised by an at least limited tradition of independence and entrepreneurship. Last but not least out of fear of local mutinies, the governments in the Communist era allowed and fostered sectors of small craftsmen's workshops and, to a greater extent, private agriculture. Furthermore there is a long-standing tradition of an informal economic sector. The question is whether this tradition offers a potential basis for lasting development. Given an adequate framework, it might become the source of economic initiative and development dynamics.

According to Borkowski and Marcinkowski, these very diverse and partly contradictory conditions constitute a number of dilemmas for public policy in dealing with SMEs and thus also indirectly with LMT firms. They point out that policy makers are still completely undecided about whether to follow a national or a regional approach with regard to support programmes; they see a further dilemma in the unsolved question of whether one should follow foreign models or should develop one's own models with respect to political programmes. From a Polish perspective the question is still unanswered as to whether policy can really shape the LMT situation and – if so – what type of policy can be effective. Concerning the Polish situation and possible policy measures in general, one can therefore formulate the following thesis: The present situation in Poland is very much characterised by policy dilemmas on how to promote low-tech sectors. At the moment, it is almost impossible to say which policy tasks and measures are appropriate and might be successful. Simple concepts are certainly not appropriate in this case.

Box 8: Specific Policy Conclusions

Two policy conclusions developed by Borkowski and Marcinkowski (2005) should be highlighted:

1. There exist essential differences between the Western and Eastern parts of the EU in the proportions of their economies accounted for by low and high technology firms, respectively. These differences should be taken into account when drawing up policy on the low tech sector. In Central and Eastern Europe the participation of the high-tech sector is very low. Therefore a question should be posed whether, and if so, how exist-

ing differences can be levelled out. Should the objective be to systematically expand the high tech sector and simultaneously to "export" the low tech sector outside the borders of EU e.g. to Third World countries? It seems that the low-tech sector cannot be endlessly restricted, as this can threaten the development of the high-tech sector and possibilities of high technology transfer. It must be admitted that the high-tech sector is not in a position to perform well without a close co-operative bond with the low-tech sector and vice versa. It would be a mistake to attribute absolute significance to any of these sectors. In the light of the PILOT research one thing seems to be unquestionable: these segments of the economy depend on each other in various ways (functionally, cooperatively, organisationally, technologically etc.) and each of them needs the other.

2. Simple development reserves of the LMT sector in Poland and surely in other new member states of the EU have already been exhausted. By simple reserves we mean the establishment of new small and medium firms based on small amounts of ownership capital. Resourcefulness, entrepreneurship, motivation of success and scanty personal resources no longer suffice to launch one's own company. In Poland one can notice the tendency to concentrate resources and aid around enterprise formation and entrepreneurship; less attention is devoted to supporting already existing enterprises. Perhaps an important manner of supporting already operating SME and LMT firms would be a separate European fund designed exclusively to cover (entirely or partly) the costs of introducing standardised systems of management (quality, knowledge, CRM). We mention this because both for high-tech firms and for low-tech firms operating in the West the possession of such standardised systems by firms of new member states would be a signal that these firms are in a position to meet the requirements of potential Western partners and to become a component of their value chains. We also believe that the PILOT research gives grounds for formulating a hypothesis that implementing such systems contributes to increased innovativeness of firms, in the area of organisational innovations, as well as product and process innovation.

7. Policy Issues

One of the main objectives of the PILOT project has been to make policy recommendations for the promotion of LMT sectors. On the basis of the research findings of the project, Jacobson and Heanue (2005) have identified a number of significant factors and problem situations concerning innovation policy for LMT sectors.

7.1 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 state 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 – illustrated by the Polish cases – of differences in Europe in the attitudes of entrepreneurs underline why such institutional flexibility is essential.

PILOT research suggests that Polish and other new member LMT firms 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 intersectoral 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 providing 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.

7.2 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 at improving the knowledge base and the capability of low-tech companies. This task can be realised at both the level of EU-wide support pro-

grams 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 the capabilities of companies; especially the organisational conditions and management skills regarding a more efficient use of existing knowledge should be further developed.

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.

7.3 Local Embeddedness and Network Relations

Policy tasks should focus on the development of the companies' organisational structure 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 sets 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.

7.4 Relations between LMT with High-Tech

A key policy question underlying the PILOT project was whether European innovation policy should focus on so-called 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 low- and medium- technology industries on which the European economy is actually based. An important PILOT result is that the policy issue is not a choice between these apparent alternatives.

The PILOT project showed that the vast majority 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. In a modern econ-

omy, 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 made up of LMT sectors also promotes the welfare of the high-tech sectors (Robertson and Patel, 2005). 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.

EU establish a mechanism to closely investigate the needs of LMT firms and *the desires and aspirations of entrepreneurs and managers*. From what you have hinted, it seems clear that these issues are not even on the radar screens of Commission bureaucrats and that policies are often made *in vacuo* from an informational point of view. Some mention might also be made of the importance of designing institutions for delivering help so that they correspond to the objective and cultural needs of the would-be recipients.

Box 9: Policy Recommendations

Among the main results of Jacobson and Heanue's (2005) examination of policy issues arising from the case studies is that there is little awareness of policies aimed specifically at innovation that is not R&D based. While there are significant differences among the case study firms, they to varying extents show evidence of non-research-based innovation. The policy conclusion is that the type of innovation that is most prevalent in LMT firms receives the least policy support. A main policy recommendation emerging from PILOT is then that this policy shortcoming be rectified. To underline the importance of LMT innovation, the PILOT project recommends that the proposed European Institute of Technology include a unit specifically focused on this type of non-research-based innovation.

8. Development Perspectives of LMT in the European Union

Finally, the following should be emphasised: In spite of the doubtlessly difficult economic situation of LMT industries and the challenges of globalisation and growing competition in the world market, prospects for LMT sectors and companies are not at all bad even in countries with advanced economies. This is true for a number of reasons:

- Firstly, the specific competences which many low-tech companies possess cannot easily be copied by potential competitors because they are deeply embedded in the social system of a company and its local environment, which makes them difficult to

transfer and thus fairly inaccessible to competitors (cf. Maskell, 1998). This – paradoxically – applies to standardised products which are usually considered easy to imitate. But such products are often design-intensive and have major potentials for technological upgrading via the use of complex knowledge inputs.

- Secondly, the geographical and social proximity to sales markets and specific customer groups as well as the capabilities of many LMT companies to use and influence these advantages in a flexible manner, are a further important reason for the relatively favourable development perspectives of such companies. For low-cost competitors from other countries, on the other hand, it is often a time-consuming and difficult task to establish the necessary contacts and to gain the required information.
- Thirdly, a considerable number of low-tech companies are obviously in a position to employ high-tech process technologies systematically and efficiently. Their specific process skills on the one hand, and frequently also their well-established contacts to the manufacturers of such technologies, form the basis for this achievement. Quite evidently the high-tech environment is a central requirement for the development perspectives of low-tech enterprises in this case.

These considerations should lead to a new understanding of the restructuring of the economic landscape of Europe in the first years of the 21st century. The economy does not appear to be undergoing a wholesale structural replacement of “old” sectors with “new” ones, or a substitution of “old” technologies with “new” ones. In fact, 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 wrongly termed low- and medium-tech industries. And it is characterised by a specific combination and continuous re-combination of high and low-tech.

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. The relationship may, in addition, be the other way around, i.e. technology creating the foundation for scientific knowledge (cf. Kline and Rosenberg, 1986). LMT industries are well placed to play a decisive role for innovations 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 prod-

ucts. As is convincingly shown by Robertson and Patel (2005), 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 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 in 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 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 low-tech industries, not least in the high-tech-oriented countries of the European Union.

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