PILOT

Policy and Innovation in Low-Tech

Organisational learning

– k*nowledge management and training in low tech and medium low-tech companies* –

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Low-Tech as Misnomer:
The Role of Non-Research-Intensive Industries
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With special regard to matters relating to the work force the paper discusses distinct features and strategies of LMT companies which allow them to generate and reproduce a competitive and innovative knowledge base. It addresses two main questions: What characterises knowledge management and personnel policy in successful LMT companies? And how is knowledge in LMT companies being created, organised and mobilised in the long run? Both knowledge management and personnel policy are activities of major importance for the development of what we call transformative capabilities of a firm. This concept refers to processes of adaptation, use and recombination of available knowledge, processes which are shaped internally mainly by a company's technological or organisational means of knowledge management and by its dominant personnel policy (including training and the use of skills and qualifications). The authors present evidence from the PILOT company case studies that LMT firms are characterised by a predominance of incremental knowledge accumulation and of informal training on the job. The paper concludes with the thesis that though these LMT specific ways of knowledge management and personnel policy add to high transformative capabilities they may at the same time be an obstacle to the creative reproduction of transformative capabilities in the long run.

1. Analytical starting-point: The LMT company

The conceptual and empirical investigations within the PILOT project followed the main objective to identify specific knowledge bases of companies that enables innovation and knowledge creation in **low tech and medium-low-tech industries** (henceforth: LMT).

Apart from analyses on the importance of a specific LMT networking and on the role of national and international policies the PILOT project tested the hypothesis that there exist certain **company and sectoral features and strategies,** which generate and recreate a competitive and innovative knowledge base. For this purpose the adequate empirical field is the structure and strategies of the LMT company. From an empirical standpoint regarding the analytical level of the low tech company the research program included an in-depth analysis of the process-related and human resource centred innovation potentials in low-tech firms.

In the results of the empirical work on the **"LMT Company"** presented here, the innovative capabilities with special regard to matters relating to the work force will be demonstrated. The aim of this article is to identify the low-tech quality and impact of organisational change across personnel and process dimensions in successful LMT companies. Therefore we try to present some answers to four key questions:

- What characterises knowledge management and personnel policy in successful LMT companies?

- What are the primary characteristics of their know-how and competences?
- How is industrial competence in LMT companies created and organised?
- How is internal knowledge managed and mobilised on the long run?

Empirical answers to these questions will be given alongside **two analytical dimensions** regarding knowledge creation and organisational learning:

- Knowledge management,
- Personnel policy (i.e. Training, skills and qualifications).

In a nutshell, in the following we try to present some empirical evidence for the main **conclusion**, that in selected low tech companies these low tech specific ways in knowledge management and personnel policy show the high performance of transformative capabilities on the one hand, but at the same time these specific modes may endanger the recreation of transformative capabilities in the long run – because of the predominance of incremental knowledge accumulation and of informal, unsystematic training on the job.

Before discussing the empirical results some remarks on the sample and methodology should be presented.

2. Methodological background

Though the project as a whole combines quantitative and qualitative research, the research on the low-tech company had mainly a qualitative focus. Altogether 43 extensive **case studies** of individual companies in eleven European countries belonging to these sectors have been realised within PILOT. Generally, the research field of PILOT is chiefly the **low-tech sector** and – as for an identification of the specific knowledge and innovation characteristics conceptually necessary – the **medium low-tech sector** of the European industry.[1] Each project partner conducted four case studies in two different branches. Thereby 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 national or regional background. The latter branch should be of specific importance regionally or nationally in terms of growth or employment.

The case studies itself consist apart from visits of the company sites mainly of several interviews with representatives of the particular chosen companies – e.g. managing directors, departmental managers for production, personal and/or R&D, shop floor personnel, works councils etc. These interviews were ‘guided’ by a common half-standardised interview

[1] According to OECD taxonomies these sectors are characterised by the fact, that less than 0,9 % and respectively 3 % of the revenue is allocated to R&D (OECD 1994; Hirsch-Kreinsen et al. 2003).

guideline. Additionally a standardised questionnaire was employed in each company, to gain the most important statistical data – e.g. company's turnover, number of employees, sum total spent for R&D etc.

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 corresponds to the diversity of this field also in terms of many other factors as well (like turnover, ownership, value chain position, batch sizes etc.). Concerning the size – in terms of work force – there are very small companies employing less than 25 workers as well as rather huge companies with more than 2500 workers.

Table 1: 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. Knowledge management and personnel policy as transformative capabilities

The traditional mindset considers firms of low and medium low-tech sectors as not knowledge intensive and therefore less relevant for the future of the «knowledge society». The idea of a new type of knowledge-driven economy usually rests on three main elements (Smith 2004):

- Knowledge is the key input, more important than capital investment or labour.
- Unskilled forms of work and employment are diminishing and employment depends on educational inputs and qualifications and specialised knowledge capabilities.
- Economic growth is based on knowledge-intensive, science-based, high technology industries.

"Europe must become better at producing knowledge through research, at diffusing it through education and at applying it through innovation" (Commission 2005). This dominant linear model from knowledge production by research to knowledge apply by innovation discriminates all sorts of non science-based knowledge and does not capture main innovation sources. Our research findings, in contrast, show the complex and dynamic knowledge base of LMT firms and their multiple forms of innovation.

The aim of this section is to identify the knowledge base of non science-based industries and firms and their forms of knowledge management. For this purpose we start with a short examination of our heuristic concepts of knowledge and capabilities before presenting our main research findings. The capabilities approach further developed in our PILOT network (see Bender/Laestadius 2005) enables us to integrate the different knowledge dimensions into a coherent analytical concept for the analysis of innovation processes in firms and industries.

"The analysis of knowledge formation in industry and technology has to start in direct empirical research capturing the variety across different realms of technology rather than in indirect collection of R&D data" (Hirsch-Kreinsen et al. 2003, see also Faulkner 1994). Our field research forced us to reconsider the mainstream knowledge concepts and indicators working with simple oppositions like codified – non codified, explicit – tacit, theoretical – practical and other similar ones. These traditional assumptions about knowledge are too compartmentalised and static and therefore proved to be unable to capture the complex and always context bounded knowledge base of our LMT firms and industries. A dynamic understanding of firms and industries as knowledge generating and innovative organisations require a dynamic and multidimensional concept of knowledge. Knowledge is an active process that is manifest in systems of language, technology, collaboration and control (i.e. it is **mediated**); located in time and space and specific to particular contexts (i.e. it is **situated**); constructed and constantly developing (i.e. it is **provisional**); and purposive and object-oriented (i.e. it is **pragmatic**); and embedded in unequal and contradictory social systems (i.e. it is **contested**) (Blackler 1995).

A look at the current knowledge debate (Lam 2000; Serra Ramoneda 2001) allows us to distinguish various knowledge dimensions relevant for organisational processes of learning and innovation as displayed in table 2 below.

To fit these dimensions into a dynamic and organisational knowledge analysis we developed the capability approach stemming from Kogut & Zander (1992) and Teece & Pisano (1994)[2]. These concepts emphasise the tacit dimensions of industrial creativity, innovativeness and management and the competence in learning and knowledge acquisition (see Bender/Laestadius 2005).

[2] "The key issue is not economic form but the capacity to create and sustain a robust architecture for generating and using knowledge from a wide variety of sources, including employees, suppliers, customers, and public bodies – which is what we mean by *associational capacity*" (Cooke/Morgan 1998, 17).

Table 2: Knowledge dimensions

	individual	*social*
explicit	Conscious (Spender) Embrained (Blackler) *Know-what* (Lundvall)	Objetivated (Spender) Encoded (Blackler) *Know-why* (Lundvall)
tacit	Automatic (Spender) Embodied (Blackler) *Know-how* (Lundvall)	Collective (Spender) Embedded (Blackler) *Know-who* (Lundvall)

Capability refers to the process of adaptation, use and recombination of available knowledge, which may be scientific, or practical, explicit or tacit, cognitive or technical. The difference lies in the combination and context adjustment. The available knowledge and the organisational capabilities are trajectory and context bounded. Knowledge is collective, interactive and socially structured.

> "Collective knowledge refers to ways in which knowledge is distributed and shared among members of the organization. It is accumulated knowledge of the organization stored in its rules, procedures, routines and shared norms which guide the problem-solving activities and patterns of interaction among members. Collective knowledge resembles the «memory» or «collective mind» of the organization (...). Collective knowledge exists between rather than within individuals." (Lam 2000, 491)

Capabilities stem from the accumulated collective knowledge as a complexity having been developed through learning processes and contain large elements of tacitness. This implies path dependence, i.e. the consolidation of an organisational learning strategy over time, which can't be changed without transformation costs and problems. Following Teece et al. (2000; 39) we understand dynamic capabilities as "the *ability to reconfigure*, redirect, transform, and appropriately shape and integrate existing core competences with external resources and ... assets to meet the challenges of a time-pressured, rapidly changing Schumpeterian world of competition and innovation." Bender & Laestadius (2005) distinguish two analytical dimensions of innovation enabling capabilities:

Transformative capability is the "enduring ability to transform available general knowledge/competence into plant/firm/task specific knowledge and competence."[3]

[3] This argument regarding crucial competencies in low tech companies is closely linked with the terms „absorptive capacity" (Cohen, Levinthal 1990; Palmberg 2001, 2002) or „dynamic capabilities" (Teece et al. 1997; Zollo, Winter

Configurational capabilities is the **"**enduring ability to synthesise novelty by creating new configurations of knowledge, artefacts and actors."

These analytical dimensions form the background of the following analysis of knowledge management and personnel policy in LMT industries, as this development of transformative and configurational capabilities mainly is organised in a company´s internal **knowledge management** by technological or organisational measures and by **personnel policy**.

4. Knowledge management in LMT industries

4.1 Strategic knowledge in LMT industries

As a **starting point** we may stress, that low-tech products are not per se non-innovative and static. The product life cycles may seem relatively long; the basic technological principles may hardly be unchanged in the long run. However, low tech products can in no way be considered as a static product. Especially regarding the whole range of products of low tech manufacturers continuous innovations and improvements are indispensable – in most cases connected with a marketing strategy of an enhancement of the diversity of products and variants. Moreover, no indication could be found, to the effect that low-tech companies are mainly producing simple mass products. Frequently, they rather seem to be flexible producers of highly customised quality parts and more and more complex products, whose share within the company's product range is widened, in most cases as a specific strategy to compete with low cost/low wage countries.

As an effect of this product spectrum nearly all forms of knowledge are used in this sector – for example, knowledge embodied and materialised in machinery, practical knowledge of blue-collar workers, technical knowledge of skilled workers and engineers, scientific knowledge of external research institutions as well as codified and tacit knowledge. In all above mentioned forms this knowledge for the investigated low tech companies can be characterised as "accumulated internal knowledge": Accumulated internal knowledge is reported as crucial by low-tech firms, as a sort of non codified tacit and informal knowledge. Often this strategic, accumulated, knowledge is concentrated in a leadership group and not dispersed over the organisation.

All firms have to define implicitly or explicitly what sort of knowledge is strategic for them and how to access and maintain this strategic knowledge. The following dimensions of knowledge management reflect the dynamic and complex process of defining strategic knowledge and generating a firm specific knowledge base.

2002). Additionally in the actual mainstream in the field of strategic management these topics are discussed in the Resource Based View of the firm (RBV) and in a Competence-Based Theory of the firm (see Frieling 2004).

- Business strategy: all firms define their strategic knowledge base by their business strategy, i.e. their way to organise production, marketing, financing, human resources, supplier and customer relations. Mass producers of simple products have completely different knowledge needs than niche producers for specialised products.
- Working process: knowledge is always collective and partly stored in rules, routines, experiences and shared norms of workers cooperating in their daily activities. The dynamic capacity of firms relies heavily on their ability to mobilise the collective knowledge of their workforce, hidden to a great extend in informal routines and shared experiences.
- Firm: every firm has its own knowledge structure and knowledge communication channels. The more flexible, interlinked and fast they are, the higher the knowledge capabilities are.
- Value chain: in modern complex business organisation the value chain is of similar relevance as the firm and concerning the knowledge management it may even be more important. The value chain is a central knowledge flow channel in low-tech as well as in medium and high-tech industries.
- Networks: it is common sense that modern economies are adopting more and more network structures and that knowledge bases are more likely to be networks than organisations (see Garibaldo/Jacobsen 2005).
- Sectors: firms and institutions of industrial sectors share common approaches to scientific and technological parameters in associations, sectoral networks, fairs, publications, etc. This kind of knowledge is public, available for every firm of the industry.
- National knowledge system: A national knowledge system may be defined as a set of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new forms and combinations of knowledge. Although globalisation is a secular trend of our economies, the national knowledge systems still matter. Public R&D policies and plans, the educational system (occupation based – firm based), the financial system (industrial – investment banking), business cultures (shareholder – stakeholder relations) and intermediate associations are important dimensions to differentiate between national knowledge management contexts.

4.2 Trends in knowledge management in LMT industries

LMT industries are by definition very small producers of new scientific knowledge but very productive in developing practical knowledge. Like other industries and sectors they are compelled to extend and deepen their knowledge base reacting to market, customer, normative and internationalisation pressures. The enhancement strategies observed in our sample are not at all different from other sectors although there is one clear and often ex-

pressed position: “we are followers, not trendsetters”. To reduce risks and costs of innovation LMT firms observe carefully the product markets, production technologies and organisational trends of their industries, evaluating their potential for their own activity and waiting for a certain maturity before implementing a new product, process or technology. Regarding that there are always few trendsetters and many followers, this might also be a more general than LMT specific business practice.

The following characteristic innovation and knowledge management strategies could be identified in our case studies.

- Intelligent imitation: LMT firms develop and improve their capability to incorporate and adjust external knowledge which has already been implemented and proved by others. Benchmarking (learning from the best) is a very common practice which requires the capability to observe, get information, analyse and transform machines, designs, organisational structures from other contexts.
- Strategic cooperation: All firms have among their disperse external relations a small set of strategic, long-term and confidence-based partners, following their business strategy. In many cases, these are suppliers of technology and machinery and important customers. But there may be also consultants, research institutes, educational and training institutions, foundations, business associations and, to a quite significant extent, informal personal networks.
- Organisational restructuring: new reengineering trends like lean production, quality management, flat hierarchies, cross functional teamwork, etc., are penetrating all firms and industries, irrespective of their R&D expenditure which implies a reorganisation of their knowledge base. However, it should be admitted that there are also several companies with very taylorised or traditional patriarchal management styles among our project firms. The organisational knowledge mobilisation capabilities are often underdeveloped.
- Corporate exchange: In several cases our companies were part of a multinational group or in close relation to one. These groups tend to intensify the interplant communication even between different economic sectors on issues like work organisation, human resources management, design, market access, etc., which enables the plants to incorporate external knowledge in a cheap and easy way.
- Accumulation and transmission of experience: Accumulated experience in the workforce is the critical knowledge asset in a huge number of our firms, responsible for specific competitive advantages, but also for certain problems like recruitment, investment in inhouse training or group egoism. Several firms told us about their difficulties in organising the knowledge turnover from the older workers generation to the younger colleagues and their problem of finding workers with specific competencies in the external labour market.

Apart from these general trends in knowledge generation and processing we could identify some sectoral trends in our sample:

Food processing is often a very science intensive activity of constant modification and innovation of products, processes, quality control instruments and health security; activities which are not at all reflected in R&D statistics. The food producers of our sample (mainly Polish and Spanish firms) are extremely knowledge intensive organisations, including knowledge on the chemical composition of their products, their physical, biological and biochemical behaviour, human nutritional requirements (incl. those for babies), the microbiology of foods, the atmospheric influences (oxygen, contaminants), the pharmacology and toxicology of food materials, the interaction with packaging materials, the effects of manufacturing operations and storage conditions, etc. This processing knowledge has to be combined with market (often local food cultures), design, logistics and organisational knowledge to obtain an operative and profitable knowledge base for their business activities.

The business strategies of food producers are to a large extent strategies to reduce the high complexity of their knowledge base. Thus, a Spanish dairy producer converted its small R&D department into a project management and coordination instrument which constantly organises projects with external partners (public and private ones, research institutions, firms, associations…), contracting external experts and developing a very diverse research activity on new products (special yoghurts, healthy food), new designs, new storage and logistics systems, etc. The knowledge management of this firm expands the knowledge base into a very diverse and wide network of external partners. A Polish example of our sample shows how a small family owned firm was able to convert a traditional way of home-made pasta production into industrial production preserving the original taste, smell, shape, structure and the components. Therefore new machines had to be developed in trial and error process using Polish and Italian technology and finding continuously new solutions to new problems, but with an R&D budget of zero euros.

The example of two Spanish dairy firms located in the same region show the decisive character of the business strategy in defining the knowledge base. For one of them, following a strategy of national leadership in milk and diversified yogurts, main innovation activities are developed in high-volume production and transport, storage logistics, package design and branding, whereas for the second one, following a customer oriented flexible niche production, multipurpose machinery and equipment, direct customer services for various types of customers (multinationals like Unilever, Nestle or McDonalds, small supermarkets and restaurants, delicatessen shops, etc.) and the product development laboratory are critical knowledge areas.

In the **metal sector,** firm specific knowledge bases are often a decisive competitive advantage in highly competitive globalised markets as three foundries of our sample illustrate. A Finnish firm is producing propellers for the ship-building industry using particular techniques for the design, moulding, casting and grinding. In collaboration with the Tam-

pere Technical University the small family-owned firm developed the world's biggest robot-based propeller-grinding line. The core capabilities of the firm in propeller design and casting are based on accumulated patterns of learning by doing and using, going back to the 1950s to the founding years of the firm. Due to family ownership throughout its history, this accumulation of core capabilities is largely facilitated by apprenticeship, from father to son and grandson. Nonetheless, during the expansive phases newly graduated engineers have gained employment at the firm and thereby also extended the knowledge base beyond family membership. This very firm specific accumulated knowledge is combined with the national knowledge system, the Finnish competencies in the field of propulsion systems, external (foreign) knowledge partners such as the main customers and subcontractors. On a very similar knowledge base a Spanish foundry supplies big castings for wind power stations and an Italian one wheels for the automotive sector. The dynamic capabilities of the firms are unique, highly tacit and localised.

In the **paper industry** we have clear differences between opposite business strategies. On the one hand we find specialised high price/high quality niche market producers, on the other standard mass paper manufacturers. For the first, traditional, tacit, personal handicraft knowledge is required and often old machines are still in use and without competition, whereas for the latter automation, standardisation and encoded knowledge in highly sophisticated high-tech machinery are the critical points. Our case studies document the high complexity and critical character of the implementation of new high-tech paper machines in the firms. Outsourcing and concentration on core competencies are widely used options in this sector. In the important paper producer countries of our project -- Sweden, Finland and Germany --, the paper industry is organised in clusters including research institutions (foundations, university institutes), transport and IT companies, engineering and chemical suppliers and customer industries like graphic, packaging, publishers or woodworking.

Our **furniture** companies (from Sweden, Germany and Ireland) belong, in a similar way as some high-end textile and special tools producers, to a very design intensive sector where flexible customer oriented high quality production makes the difference. The furniture sector offers a variety of niche markets where these producers with their unique, difficult-to-imitate products, based on high quality materials and sophisticated designs, find their profitable areas of activity. The capability to satisfy particular client demands, e.g. office chairs with customer specific designs ("customising"), is a critical competitive advantage. The strategic knowledge is based on experienced sensitive market observation to capture trends like fashionable chairs for kids or physiotherapeutic "wellness" chairs, and long-term customer and supplier relations with special emphasis on the cooperation with designers.

To take a specific example, our Irish company has a very closely cultivated relationship with a Romanian furniture company. The Romanian firm produces prototypes, solid wood components and some complete pieces of furniture for the Irish partner. Personnel from

each organisation have visited the other's premises, and workers from the Romanian factory have been employed in Ireland. In one case, a Romanian worker who previously spent two years in Ireland now works full-time for the Irish company in Romania in a quality control function for components and products. By contrast, it does not subcontract work to other Irish firms saying that they would not be able to compete with the competitive prices for solid wood components originating in Romania or other lower wage cost economies.

The shop floor organisation tends to be more automated and standardised. The knowledge base, therefore, can be described as mainly value chain based (the "extended enterprise"; Gustaffson/Laestadius 2004). The Swedish and Irish examples show a trend towards clustering, concentrating furniture competencies in a specialised region with shared resources, knowledge and support infrastructure. The raw material, high quality steel, plastics and wood, is a very science intensive field with continuously new developments.

5. Training, skills and qualifications in LMT

5.1 Transformative Capabilities and the role of training

In general in the highly developed European Countries the statement of a growing importance of **vocational education and training (VET)** within strategiess for Lifelong Learning is common ground (BMBF 2004; OECD 1997). The ambitious target in the main political programs of the EU (e.g. Lissabon declaration) is to become the most dynamic knowledge-based market in the world by 2010. In most cases this goal is substantiated with the ongoing socioeconomic change towards the knowledge society (Nyhan 2002). It must not be forgotten that also low tech industries are an active part of this knowledge society on the one hand and more or less adaptive recipients of technological advance, which is created in the knowledge intensive sectors of the European economy on the other hand. Especially because rapid technical developments and organisational restructuring lead to changes in occupational requirements at ever shorter intervals the importance of continuing vocational training is still growing – as the educational systems increasingly are only able to deliver basic qualifications and key skills and need much more time to readjust the curricula of education and vocational training systems. The gap between extended and fastened technological innovations and organisational change processes for an economic actor like a company has to be closed via short-term vocational further training.

In our **conceptual framework** personnel policy (including mainly vocational training) has to be quoted as one of the elements of what we call **transformative capabilities** of LMT companies (see above). This transformation requires the individual capital to succeed in transforming the external location factors into arrays that are subject to internal control and power – which predominantly are evident in the concrete organisation of its own production process. The central starting-point for company strategy in that sense consequently lies in the design of the production process, as the technological and organisational structures

of the production process and the forms of labour deployment determine the individual company´s chance to secure productivity by maximal use of labour force. The typical foci of strategy then concentrate on the change of technology, (work) organisation and personnel policy, which in our terms are classified as "elastic potentials" as they are the most easily controllable drivers of productivity and economic autonomy.[4] At the same time the most activities of bundling and rebundling in one of these dimensions go along with simultaneous adjustment necessities in the other two elastic potentials. From a scientific standpoint this means that for analysing the pathes of personnel policy a discussion of the complex interplay with work organisation and technology is necessary too.

In this section we concentrate on the elastic potential **personnel policy** and try to summarize the specialities and transformation processes going on at the LMT companies, we have analysed in our empirical field work. Within that transformation process low tech companies create new adaptable knowledge especially via vocational further training. In a dynamic dimension vocational further training improves the transformative capability of the firm in itself. So the basis for a dynamic perspective on transformative capabilities lays in a permanent creation, recreation and transformation of qualifications and skills. The predominance of in-house training activities may also be seen as an indicator for the necessary contextualisation of knowledge; global available knowledge is not simply replicated locally, but only certain aspects of global knowledge are reconfigured in company specific training activities which are closely obliged to the immediate use of workforce within the production process. Any surplus accumulation of skills and qualifications is avoided – with some exceptions at the qualifications of the managerial staff.

As the main drivers – independent variables – of internal training measures act organisational characteristics and **changes in the work organization and technological innovations** in the production process, which meet a specific **workforce supply** by the education system on the labour market. If the last doesn´t deliver enough skills and qualifications in a sufficent quantitative and qualitative peculiarity, which fits the specific needs of the company, the way to recruit people on the external labour market is blocked and the firms have to neutralize these constraints by internal pathes of vocational further training. Vocational further training by means of in-company on-the-job training measures in the enterprises itselves thereby is mainly directed towards the adaption of skills to a new technical and occupational environment. The starting point for a low tech company in most cases is not vocational further training per se to enhance the work force level as a principle in itself, but a very clear impulse, which results of organisational and/or technological restructuring as a company strategy to follow customer demands or to cut costs within the production process. Therefore herewith we start with some remarks on the current technological and organisational changes in the analysed low tech companies.

4 For the theoretical background on the so called "munich strategy approach" see recently Schmierl, Pfeiffer 2005; originally: Altmann, Bechtle 1971.

5.2 Technology and the role of automation

Low tech companies are characterised by core competencies in processing technology and logistics, which strategically are structured and changed in order to produce uniqueness and continuous competitiveness. The term low tech as a classification of sectors is thus not synonymous with **low tech manufacturing processes**. On the contrary complex (semi-) automated production facilities are deployed very often. Insofar the production process entails specificity in the manufacturing process as well as in the processes of supra-company distribution and supply logistics. The main strengths of the competitiveness secured by low tech companies in European high-wage-countries are thus the long-term and gradual optimised manufacturing processes and the permanently accumulated know-how for to running these processes.

The concrete shaping of the production process regarding the use of advanced machine equipment in the investigated low-tech companies is manifold. The bandwidth reaches thereby from companies using most modern machinery and highly automated processes (especially in the paper industry, but also in parts of the metal working industry) to companies, which are hardly automated and still rest to a great extent on traditional manual labour (like in the food or wood processing industry). The latter type is often a result of a lack of financial means, but as well often the consequence of a cost cutting strategy. In such cases usually work-shop production is applied, whereas sometimes simultaneously state-of-the-art machinery – but not in terms of automation – is in use, too. In contrast, line production with high automation degrees is predominantly applied, if standard mass products with little variants, such as mass paper or metal bars etc., are manufactured.

Corresponding to these findings it turned out that low-tech companies often differentiate their production process in uncritical **routine phases** and **critical phases**. The former are mostly unchanged standard processes, whose running is ‘unproblematic’, while the latter are strategic, vital and knowledge-intensive, and thus require a higher skill level and different forms of knowledge. This can also imply distinct process technology and types of work organisation. Thus the low-tech sector can also be characterised by a **co-existence of modern**, sophisticated production means and processes on the one hand **and standard technology** and processes on the other hand. While the use of modern technology is predominant, this must not include the whole production process, as these low tech firms often use a cost-cutting combination of old and new technology: Many of our firms are characterised by simultaneous use of old machines and technologies and new incorporated production technologies where the old and proved one serves as flexibility buffer.

As a consequence of this simultaneity of old and new machinery and of critical and routine processes we have to state a bandwidth of transformation strategies regarding training in the low tech companies between nothing training at all and systematic in-house and external training activities for to adapt new job requirements stemming from technological implementations.

5.3 Work organization and skills in LMT

The same holds true for the change of work organization. First of all and not surprisingly, according to our sample there is **not one common pattern** in the so-called low-tech companies regarding work-force and work organisation. That implies that there is definitely no low tech specific pattern of work organisation, work force and qualification level, 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 thereby determined by an interplay of many different factors – such as product complexity, production process characteristics, machinery and automation, personnel policy, market situation, quality requirements and customer demands etc. In some cases different forms of work organisation are applied within one company. Thus, simplistic pictures, which consider this sector as obviously respectively naturally dominated by unskilled labour, a certain type of work organisation with an extremely high division of labour, strict hierarchies etc., must be repudiated on the basis of our data.

Nevertheless, forms of **strictly taylorist-hierarchical** work organisation are indeed prevailing within our sample. Its main characteristics are a high division of labour, a heavily specialised work-force and sophisticated hierarchic levels. Furthermore there is a strict separation of conception, planning, steering and control, conducted in technical offices, on the one hand and the subsequent execution, taking place within the shop-floor on the other hand.

More **participative** forms of work organisation like semiautonomous group work, involving typical characteristics such as job-enlargement, job-enrichment, flat hierarchies and a low level of division of labour, are primarily applied in the investigated low-tech companies, if there are complex production processes with sophisticated machinery and a high level of automation. In a few cases there occur also organisational restructuring measures towards more autonomous forms of work organisation due to a priority setting within the company's personnel policy with the objective to enhance flexibility and short reaction times.

Of course there are also intermediate forms of work-organisation, which can be considered as **polarised** work-organisation. Thereby the division of labour between pre-production planning departments and the manufacturing is maintained in fact. However limited functions in terms of disposition are shifted now towards the production, whereas such functions stay located within the ranks of executive productive personnel such as group leaders, foremen or master craftsmen ("Meister"). Moreover the qualifications of the productive workforce are on the one hand to a lower extent differentiated and on the other hand the overall qualification level is higher than in the first model – it ranges from semi-skilled to skilled.

Regarding **sector peculiarity** and characteristics of the product range the cases of the food sector come closest to a taylorist and hierarchic type of work organisation, while the in-

vestigated companies of the paper sector are characterised by a high relevance of skilled work force[5] and relatively advanced types of work organisation – often due to the use of sophisticated machinery and the decoupling between the production process and work activities (here often control stations are implemented). In between these two poles the modes of work organisation in the wood and furniture industry, in the textile industry and in the metal working industry are located, while in the latter we found also innovative modes of work organisation.

For the **near future** we were not able to identify a definite trend, as the companies follow one of two contrary strategies: Deskilling of production workforce together with the concentration of the competence at the white collar workers on the one hand versus a general enhancement in skills and qualifications on the other hand. The bulk of our firms indeed is characterised by the concentration of strategic knowledge and competencies in a rather small group of managers and technical staff while the production workers are more or less skilled executers. However, there are a growing number of firms introducing new communication and organisation schemes like cross functional work groups, problem solving groups, continuous improvement schemes and lean concepts.

5.4 Training in LMT companies

A rather heterogeneous picture then has to be presented regarding the **skill level** within the sample. There are companies employing mainly unskilled workers, while there are others relying heavily on a skilled workforce. In such cases workers' knowledge and competence is often identified as crucial for the company's success. Thus to concede a general irrelevance of workers' knowledge in the production process is misleading. However, in some cases the management opted for skilled workers not so much because of their distinct qualifications and skills, but much more because of their professional attitude towards work. A skilled work-force is thereby considered to be more co-operative, loyal and thus less likely to cause disciplinary problems or even conflict.

Regarding **recent respectively planned changes** of the work organisation there is no homogeneous pattern as well as there is no significant stepping up of efforts regarding rationalisation and restructuring of the work organisation, for example like a trend towards group work. The work organisation stays thereby mainly subordinated to the technical equipment used in the production process. Consequently, restructuring of work-organisation and workforce in most cases is induced by changes of the machinery. All in all, also in LMT

5 The term „skilled staff" in our terminology characterises highly trained personnel, who has finished their vocational education and hold sector or process specific certifications of apprenticeships, which last about two to three years. Semi-skilled workers have no certifications, but have taken part in operator training measures and gained (mostly) company specific competencies and experience by specific courses and training on-the-job. Unskilled workers possess neither of these two qualifications/skills/competencies; for the practical work basic school education and a short introduction to the job are sufficient (Jedermannsqualifikationen).

firms we face a very close relationship between technological innovation, organisational restructuring and training measures.[6]

Therefore in our analysis on training measures we have to differentiate between low tech companies which have changed their work force related strategy due to far-reaching organizational or technological innovations and low tech companies which follow an unbroken standard personnel policy regarding work-force and qualification. In the last case the low tech companies of our sample additionally practiced several activities within personnel policy, so that, all in all, five **modes of personnel policy** can be defined, which are mostly complementary, phase specific and partially differentiated between different workforce categories:

1. An advanced personnel policy including an integrated work organisation, technology and workforce related strategy
2. A non systematic personnel policy and muddling through
3. Incremental internal on-the-job training and informal further vocational training
4. Recruitment activities on the external labour market
5. Vocational training networks and learning alliances

(1) Advanced personnel policy including an integrated work organisation, technology and workforce related strategy

The companies of the first type, which employ a very modern, capital-intensive and highly automated production process, follow an **advanced personnel policy including an integrated work organisation, technology and workforce related strategy**. This type was found in our cases of the paper industry[7], of the metal working industry and in some cases of the food processing industry (e.g. dairies). In these cases the tendency towards automation does not lead to a de-skilling of the work-force, but vice versa to a stronger demand of skilled workers. This is a result of the growing importance of a continuous and quick maintenance of the machines. Thus the ensuring of a friction-less production is the crucial challenge for the companies employing a modern production process. As these activities can hardly be standardised, automation in most cases of our sample is linked with the utilisation of skilled workers. This challenge – to avoid frictions in the production process – is

6 In order to highlight this relationship and to demonstrate the broad variety of the companies´specific problem and surroundings situations as well as the bandwidth of company solutions in the area of personnel policy and training in this section we refer more detailed to our empirical case studies.

7 The investigated companies of the paper industry are characterised by the use of sophisticated machinery; apart from one company there are highly automated production processes. The skill-level is relatively high – it can be characterised as an at least medium mostly high skill level. Thereby (semi-)skilled workers are prevailing – in one case only skilled workers are employed. There are hardly unskilled workers. Vocational training plays an important role in most of the cases (mostly on-the-job training). In two cases there is even a rather high level of vocational training. In these cases external vocational training is applied as well.

also reflected in the work organisation. The hereby adapted strategy is, to reduce the division of labour so that the same workers, who run the machines, are liable for its maintenance and tasks within production planning and scheduling. Therefore forms of semi-autonomous group-work were implemented. Through job rotation, job enlargement and job enrichment, the work-force fulfils a greater variety of work-tasks and thus overcome sudden changes in a complex production process. Thereby the goal is often to enhance the companies´ competitive advantage via an increased organisational flexibility in personnel policy; job enrichment enables quick changes in the production process and makes the company less dependent of single key workers.

The example of a **German paper mill** with approx. 100 employees[8] may stand as a prototype for a systematic improvement of transformative capabilities in the paper & pulp industry.[9] In general the innovation processes in this sector can be differentiated into two phases. There are **periodic fundamental innovations**, which are always connected with very high investments in the development – or better: the purchase – of a new paper-machine. Such a 'break-through' is usually followed by a series of **incremental innovations**, which are additionally needed to yield the maximum return of the high investments of the past. Apart from improvements of the paper-quality, innovations oriented towards an enhancement of productivity or to lower costs are largely prevailing in the dominating field of mass-paper production. As in the late 90ies during the new economy boom the demand for newsprinting paper increased significantly, the analysed paper mill thought of enhancing their production capacity in this sector. After the idea was given up to modernise an already existing company site it was decided in 2000 to found a legal independent subsidiary and thus to build up a totally new plant with extraordinary modern machinery and rather innovative organisational structures in the green field. Within the process the paper-machine plays an outstanding, 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. According to the company's business strategy requiring total productive maintenance the production process is characterised by a very modern and innovative **work organisation**. 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 on its part be further differentiated into four teams of three and one team of two – whereas each team is 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 self-responsible. 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 various tasks and activities. Quite remarkably each shift is namely not only responsible for the running and operating of the machine, but also at the same time for its maintenance. The reliance on the knowledge of its workers is foremost reflected by the fact, that only **skilled workers** are employed. Thereby it is interesting, that only a minority of the work-

8 In Germany the international paper industry group employs about 2500 workers in total.

9 Similar farereaching reorganisation processes occure at **a Swedish paper mill**, without restructuring the work organization, use of qualifications and training in such a progressive way as at the German plant.

ers are explicitly trained as paper-makers or could yet gain any practical experience regarding paper production, when they started to work in the company. Because of this lack of practical experience resp. knowledge, the new workers were sent for four months to another paper plant of the company before they began to work at the company. There they could gain by various training-measures the necessary basic (practical and theoretical) knowledge about paper production. Apart from the paper-makers most of the workers were initially skilled mechanics, electricians or chemical workers. This specific composition of the work force is not so much a result of recruitment difficulties – though there actually existed serious problems – but much more a consequence of the company's special work organisation. The model of integrative maintenance namely requires **hybrid qualifications** – within the entire workforce and even within the single work teams. Furthermore it was aimed, that by the implementation of these teams a flux and transfer of knowledge is enabled. Thereby **a reciprocal training-on-the-job** of the employees shall be initiated, in the sense that for example the mechanics train the paper makers regarding the maintenance of the machines, while in turn the paper makers 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, the workers of the company must work 39 hours. In the additional hour the employees are obliged to take part in on-the-job training – e.g. to learn to operate on different sections of the paper machine. Thereby it is striking, that the concrete proceedings of this training are not determined by the management. Much more the complete training – even the timing – is organised quite autonomously by the employees. Only its content is reconciled with superiors according to production necessities and the company's business strategy.

(2) Non systematic personnel policy and muddling through:

The contrary type is characterised by a **non systematic personnel policy**. In these low tech companies routine processes are dominating, the production process is well developped and mature, the product characteristics do not vary in a considerable manner, no distinct changes in the technological or organisational equipment are necessary. Within these low tech companies the relevant production process knowledge is mainly spread among specialist engineers, master craftsmen (foremen) and skilled workers. Specialist engineers come from a variety of academic backgrounds including mechanical, chemical, electronical and sector specialist (textile, paper, wood) engineering. At the same time on the regular work force there is a considerable underdeveloped potential in low-tech firms to improve the knowledge base of their work force by strategic training and qualification and participative work organisation. This mode seems to be dominating in the investigated companies of the furniture industry, the textile industry and the labour intensive sections of the food sector.

For example in some investigated companies of the food sector mostly unskilled workers are employed in the production, while their knowledge is not very crucial for the company's success. This is reflected by the fact, that the shop-floor workers seem to be fairly exchangeable, as seasonal, short-time workers and forms of precarious work are a common

practice. As a result, on-the-job training plays a subordinate role as well. These companies offer no systematic continuous training. For the practical work basic school education and an extremely short introduction to the job are sufficient.

There is one furniture company, which claims, that they could run the whole production process at the same efficiency level within three months, if the whole production staff was replaced by a new workforce – whereas this would hold only true, if the supervisory personnel was kept. In some low tech cases we found for example permanent efforts to replace human productive knowledge (incorporated in skilled craftsmen) by increased use of embodied knowledge (e.g. at an Irish furniture company). A further example for this pattern is the case of a German manufacturer of swivel chairs. It employs predominantly semi-skilled workers, as the production process requires no elaborated skills. The relative high share of temporarily leased workers and the non-existence of a works-council demonstrate the easy replacement of the workforce here either.

(3) Incremental internal on-the-job training:

The **"usual" way of enhancing the skill level** in the production of low tech companies and of instructing new work force in the firms´ specialities, however, are forms of incremental, permanent **training on the job** on varying skills levels by experienced colleagues. A very important source to innovation is the experience of the engineers who have worked for many years within the company. They have an enormous knowledge of the industry and good insight in what has already been done and what will or will not work. The educational background of the engineers and workers (as acquired through academic and/or vocational training) serves as solid knowledge base for the integration of the company specific experience and know-how as well as a foundation for permanent and regular extended vocational training. The importance of experience based practical knowledge in low-tech firms gives priority to **internal on-the-job training**, often organised as knowledge transfer from older to younger employees. At the same time the technological and labour market changes permit the incorporation of higher skilled young workers who combine the experience of their older colleagues with their technical and organisational skills. Several firms, however, reported difficulties to recruit workers with specific skills required for their production processes which also makes inhouse training necessary. The acquisition of knowledge in low-tech firms often takes the form of experimental learning by doing trial and error processes giving results that are hardly documented. The dominance of internal training also reflects the deficient vocational training systems in many countries. Although schooling has provided the shop floor workers with the basic production knowledge, in many companies it is highlighted that the specific knowledge of the production activities can be only acquired by longterm working at the company. Such rather relevant knowledge of the production activities is thereby mainly acquired by **experience** respectively working at the specific company. In some cases this implies little formal documentation, and a per-

sonnel policy, whereby knowledge is preserved and accumulated through a low turnover of personnel and through being passed on from seniors to new recruits. The often low turnover of personnel together with these learning by doing phases gives low tech companies a large 'pool' of accumulated knowledge. As a consequence these companies pay much attention to the skill-level of their workers as well. Forms of internal training here play usually an important role either.

As a welcomed **side effect** thereby staff members are very much tied to the company because there is little demand and employment in other companies or sectors for their specific qualification profiles. This is a result of the long-lasting internal training phases but also of a lack of national educational and vocational training systems, which in many cases are not able to make the demanded skills and qualifications available.

In a Swedish wood processing company with 100 employees the strategy is to focus further on the knowledge of the company's blue-collar workers. This decision is a consequence of a very complex production process, in which no-standard and high-quality products are produced. Thereby the required craft-like skills of the workers can't be substituted by more modern machinery. Not surprisingly, internal vocational training plays an important role in this company. This is also due to the effect, that there are recruitment difficulties.

The shop-floor and white collar workers in this kind of companies often have been working for years in the same company and hence could gather a broad experience with the specific production processes and the applied machinery. Their hardly codifying knowledge is important for the smooth running of the production process, as only through 'learning by doing' and not by standard vocational training the necessary practical experience, how to handle this kind of machines can be learned. While at the Swedish producer of hand-tools there are detailed instructions for the running of the machines, in the end it seems solely to be the experienced and internal trained personnel, which has the instinctive knowledge and sense of 'how things are done' in order to run the machinery efficiently. Practical knowledge (including tacit knowledge), and in particular learning by doing, is extremely important in low tech companies on two levels. The first is for the machine setters and their ability to pre-empt problems in the running of the machines. The second is at the level of team leaders, engineers and maintenance. Not only are these people critically involved in the setting up of the machines and tooling but they are also critical to the incremental process innovations that characterise the innovations that take place in LMT companies.

In general in the companies of our sample investments into training and further training have been growing constantly over the last few years. Trainings are held predominantely in the form of in-house and only in exceptional cases by external seminars. In addition to technical seminars (new technologies, IT), courses in corporate culture, languages and communication, as well as courses for the intensification of customer relationships are offered. The courses are organised by a wide variety of organisations, trades associations, technical institutes or specialised education companies.

The knowledge required by an Austrian railway track and system manufacturer (400 employees) and another Austrian producer of long steel products (100 employees) is of a very special type and calls for intense and long-term on-the-job training in order to ensure that staff will meet the requirements of practical work. Actually, a cycle has been set up that passes on practical hands-on knowledge of experienced staff to their younger colleagues, who in their turn will pass it on later. This may take place in a formal frame of internal education and training or by way of an informal "on-the-job" training. Because the company needs personnel of a specialised qualification profile, it cannot rely on recruiting fully trained workers. By far the most workers come from such internal training courses; the specific knowledge base makes workers from other companies and/or sectors a rare exception. For this reason, it provides extensive in-house training for metal workers tailored to the specific needs of a rolling mill for long products and rail producer.

As an often applied element of this usual policy for the **internal incremental enhancement of skills and qualifications** in the investigated low-tech companies processes like interactive learning and models for to record, formalise and generalise internally already existing knowledge are quite important – e. g. via suggestion boxes, **continuous improvement programs (CIP),** brainstorming meetings, Competition of Ideas or project groups. In the case of a Spanish manufacturer of railway tracks for example a distinct internal program was launched, through which workers were urged to write down the working processes and make public their individual knowledge. Continuous meetings at all levels are held, suggestions are encouraged and the competition of ideas has become institutionalised. Sometimes these measurements are really sophisticated and are considered by the management as quite important for the company's success. Such 'organisational tools' can be quoted as personnel policy and training elements, which shall thereby also ensure a better bottom-up flow of knowledge. They are often connected to further efforts to codify personal knowledge, which shall be made accessible to the whole work-force – e.g. via the intranet. But, compared with other economic sectors, such forms of knowledge-management are neither in terms of frequency nor in terms of intensity rather outstanding or low tech specific.

The forementioned Austrian railway track producer invests substantially in the education and training of its staff. The Group-wide "life programme" guarantees each staff member that 3% of their working hours may be claimed for further training. Initially developed for older employees to make better use of their potential and counter the pending shortage of skilled workers expected for demographic reasons, the programme has since been opened to all staff members. It offers both technical and personal education and training courses. This firm has its own intra-company training programmes and does as well participate in staff training programmes with other companies and organizations. Continuing education and training ensures a renewal of one third of the intra-company knowledge base approximately within 10 years.

(4) Recruitment activities on the external labour market:

While this internal learning on the job and a longlasting working for the firm sometimes is also the basic for the announcement of **white collar workers**, group leaders and produc-

tion **managers** via a continuous upgrading of qualifications, an exception of this predominance of internal recruitment and training scheme are key positions. These often academic qualifications have to be recruited on the external labour market.

At an Italian textile industry firm with 30 employees for example the majority of its employees are in production (18), with 4 in production planning, 2 in purchasing, one in sales, and one in commercial management. The design process is completely outsourced to designers in New York and Paris, who work as consultants for the textile manufacturer. The highly trained internal workers, like model makers and prototypists, are, as the designer freelancers, highly specialized and were trained professionally externally at design schools. Not only do they have specialized training in design, sewing etc. but they also develop a "sense" for the market through their travels and observations of other designers´ work. On the other hand very little knowledge comes from training programs for the textile workers. In terms of production, there are no schools for seamstresses and the company does very little training. Therefore workers learn simply on-the-job.

But due to the high importance of firm specific knowledge also these external recruited academic high potentials often have to be **trained within the company** for a certain period after finishing their studies.

At the Austrian railway track and system manufacturer engineers and graduates of the nearby University and the technological universities (study courses in mechanical engineering) are typically recruited directly upon completion of their studies and given an internal on-the-job training in highly specialised departments. Engineering or technological studies at best provide graduates with a solid foundation, but are too general in scope to enable individuals to be immediately placed in a practical position without any deepening in the relevant field.

In the most cases there is a long-lasting **tradition of an internal promotion from shop-floor to 'white-collar' positions**. Promising employees in a longterm perspective are trained systematically often by job rotation and practicing in several departments of the companies. Trying to store the supervisory, technical and commercial competencies and knowledge, within the companies, is an important issue. There within many low tech firms is a culture of progressing people up through the organisation. This kind of targeted human resources development ensures that leading positions can be filled with people from the company's own ranks. For example, management and white-collar staff often are exposed to other areas of the business in order to give them a broader experience by hospitation in several departments of the LMT firm.

At the same time these internal promotion pathes and career ladders serve the objective to organise the know-how and knowledge transfer from the established workforce to not so experienced colleagues. The way to keep these crucial competences within the company is by continually passing the knowledge on to other personnel and trying to keep those people within the organisation. In addition, to avoid frictions by fluctuations low tech companies also ensure that a number of people are exposed to each role, so that there is someone who has the ability to take their place at least within several weeks. Therefore, the circulation,

encouragement and job enrichment of employees is a constant process. Therefore in LMT firms there are defined certain carreer paths for well-performing staff members.

This mode for example is found at a Swedish producer of sanitary armature with about 600 employees: The great amount of practical and engineering knowledge is a result of a managerial system that has highlighted and rewarded technical knowledge by promotion. For example in the product development department some employees started their careers in the production line and then advanced from blue-collar to white-collar positions. This manner of advancing within the company is not specific for the development department, but has been the traditional recruiting procedure. The use of apprenticeship programs within the production department is frequent, much due to insufficient (re)sources of formally educated people in the region and the specificity and thus lack of appropriate formal training in some of the production processes.

(5) Vocational training networks and learning alliances:

A fifth element of vocational training and further training for low tech companies are **vocational training cooperations** with external institutions or companies of the same sector and region. In some instances problems in recruiting skilled workers occur when specific product aspects demand for qualifications (as in plastics molding or the competence of the smiths, for example) that are not adequately provided by the national systems of vocational education and training. In addition, often vocational profiles in the low tech industry are largely unknown to young job seekers and trainees. The companies respond to the recruitment difficulties with a different extent of initiative. Many simply intensify their training on-the-job to incorporate new staff. Other companies of the sample employ distinct apprentice-ship systems. And some companies follow an innovative cooperation strategy regarding personnel policy which shall help to close the supply-demand gap by common training networks with municipalities or other companies. One company even started an upper secondary school education in collaboration with municipalities.

A few years back, the Swedish hand tool manufacturer with nearly 400 employees experienced difficulties in recruiting new shop floor workers much because of the economic upswing. The production is highly labour-intensive. In order to assure future personnel resources to the production, the company started its own upper secondary school education, Industriprogrammet, in collaboration with the municipality of Enköping. The school has its own premises within the factory and some of the firm´s personnel work nearly full time as teachers at the school. Apart from Industriprogrammet, the company has the altogether state-owned company Lernia in the very same building. Lernia is dedicated to skill enhancement and vocational training of adults. The tool manufacturer recruits personnel on the recommendations given by the school. Aside from being a source of new personnel, Lernia also offers education for the employees on a continuous basis.

Similarily a Spanish metal working company due to a lack of specialized foundry workers, created its own, officially recognized, vocational training centre.

An Irish producer of metallic precision components with about 40 employees is a part of the North Mayo Skillnet Training Network. This network was devised as an approach to filling skill gaps and training needs for a group of nineteen companies in North Mayo/South Sligo. The companies range in size from five to 300 employees and they are engaged in widely different sectors of industry and business. The network was first established in 1999 and has grown from an initial group of 4 member companies to its current number of nineteen. The objectives of Skillnet are to sustain employment in the region, to enhance competitiveness, to create added-value, to make training more innovative and available locally and to become the recognised training centre of excellence. The respective metal working firm is also involved in the Mayo Engineering Association – another training body linked with the National Training and Employment Authority for Ireland (FÁS). Currently, this firm is also examining the idea of APL – accreditation of prior learning – that would be carried out in conjunction with FÁS. The idea is that the existing skill level of those without formal qualifications is assessed, examined and certified, and courses devised for any areas where there is a need for improvement. It is envisaged that a programme of APL would be initiated within the coming year. The company's management regularly emphasised the importance of harnessing the potential of the employees. This has ranged from the development of training plans so as to facilitate APL to the promotion of soft skill initiatives and team building exercises.

6. Summary of core findings

The results presented here have shown that both knowledge management and personnel policy are activities of major importance for the development of transformative capabilities of LMT companies. Primarily human labour and work-force is the moving force of knowledge management and transformative capabilities. With special regard to matters relating to work force we demonstrated distinct features and strategies of LMT companies which allow them to generate and reproduce a competitive and innovative knowledge base. The herewith presented empirical results delivered some evidence for the conclusion that LMT firms are characterised by predominance of incremental knowledge accumulation and of informal, unsystematic and also incremental training on the job.

6.1 Core findings on knowledge management in LMT

The key to define knowledge management in LMT industries is shared experience in firms, industries and networks. Our research results confirm that there are significant and relevant non-R&D knowledge bases and inputs to innovation. LMT firms are continuously innovating in marketing, design, logistics, processes and products through the incorporation of external knowledge and the accumulation of internal practical knowledge, recombining the heterogeneous knowledge elements and adjusting them to their specific needs. Although they are not scientific knowledge producers they are indirect users of R&D outcomes by incorporating them into their firm specific knowledge base. The specific R&D/science use of these industries is not measured with available indicators.

LMT firms and industries are active elements of regional and national innovation systems forming part of complex value chains and economic clusters. By intelligent imitation and recombination they contribute to the improvement of apply-orientated and practical knowledge base of our economies, to new qualifications and competitive strategic know-how.

On the other hand, a comparative view of our sample offers huge potentials of underdeveloped use of internal and external knowledge sources, often due to traditional managements styles and/or organisational lacks. This points to political questions of how to improve the knowledge management capabilities of LMT firms in order to enhance their contribution to growth and employment in Europe. Horizontal politics and networking are key issues improving the associational capacities of our knowledge based «associational» economies.

Finally, comparing our findings with recent trends in so called high-tech science-based sectors like ICT, pharmaceutical and specialist chemical industries show again the misleading orientation of concepts centred on R&D intensity.

> "The [high-tech] companies had historically relied heavily on their strong in-house R&D but this model was rapidly breaking down during the 1990s as they sought to speed up product innovation and broaden the scope of their knowledge base. All the companies have sought to move away from the linear models of R&D towards the integrated network model in recent years. (…) In most of the companies, the corporate R&D function has become much smaller than before and in some cases, it performs primarily a networking and coordination function within the distributed R&D networks." (Lam 2002)

Networking capacity and transformative capabilities move to the centre of knowledge management in high, medium and low-tech industries in all advanced economies. The staff involved in the strategic knowledge base of the firm is not only, or not even primarily, required to be excellent technical experts but are expected to operate in a flexible, transdisciplinary and interactive mode, engaging in strategic and operational partnerships with suppliers, customers, alliance partners, external research institutions and, last but not least, the shop floor of the own firm.

6.2 Core findings on personnel policy and training

The main strengths of the competitiveness secured by low tech companies in European high-wage-countries are the long-term and gradual optimised manufacturing processes and the permanently accumulated know-how for running these processes. Especially because the adaption of rapid technical developments and organisational restructuring lead to changes in occupational requirements at ever shorter intervals also in LMT firms the importance of continuing vocational training is still growing; this is also due to the fact, that the educational systems increasingly are only able to deliver basic qualifications and key skills and need much more time to readjust the curricula of education and vocational training systems. The gap between extended and fastened technological innovations and

organisational change processes has to be closed via short-term vocational further training within the companies.

Low tech companies do not automatically use low skills. There is a broad variety of qualifications and skills with different forms, where and how transformative capabilities are located internally. In principle we identified two different modes: a generally high skill level versus polarised hierarchical layers with a concentration of dispositive tasks at foremen or white collar staff. All in all, the investigated low tech cases show that regarding the "progressiveness" of new forms of work organisation this segments seem to be followers (to what is known from other non low tech sectors) more than trend-setters incorporating new technologies, organisation concepts, designs and so on after being proved by others.

The strategy of adaption and adjustage of external knowledge sources by use and improvement of transformative capabilities does not imply that the companies buy strategic qualifications on the external labour market as foresighted personnel policy. On the contrary they apply a personnel policy which relies heavily on the predominance of internal training, which is supplied mostly unsystematically during the daily work and at the workplace. In most cases there are **forms of vocational further training** predominant with a great bandwidth regarding its intensity.[10] If there is a high level of training measures, this is often the result of inadequate regional or national educational systems, which cannot provide enough adequately skilled workers. Thereby mostly internal vocational training – in terms of training on-the-job – is predominant.

Concerning human resource management (HRM) forms of in-house promotion are rather common in the investigated cases. Quite often the executive personnel are recruited from the ranks of the blue-collar work-force. In few cases these labour market circumstances lead to a systematic training of apprentices: The difficulties to recruit specific skilled workers motivated several firms to agreements with the employment administration on the implementation of firm related apprenticeship systems.

As the predominantely applied policy for the **internal creation of knowledge** in the investigated low-tech companies additionally primarily process related improvement activities like interactive learning and models for to record, formalise and generalise internally

10 This trend seems not to be exclusive for low tech firms. A representative survey on the vocational further training situation in Germany for the Federal Ministry or Education and Research resumes that in 2003 26% of the total workforce took part in further education as well as in advanced vocational training measures (BMBF 2005, p. 15). Regarding different age cohorts younger people between 19 and 34 years old are participating in vocational further training above the average with 29%, while the first rank belongs to people between 35 and 49 years old, of whom 31% completed vocational further training courses (p. 26). Regarding the education level of trainees there a linear progression of participation on vocational further training is prevalent: while only 16% of people with a low education (lower secondary level) participated on these courses it have been 32% of people with middle education (upper secondary level) and 38% of people with abitur (grammar school=A-level) (p. 28). The same holds true for the relation between participation rates and the occupational position: 22% of the unskilled and semi-skilled workers, 38% of skilled workers, 34% of white collar workers and 63% of managers took part. A high and growing importance for all categories of workforce gained (with a participation quote of 61%) different activities of informal vocational training on the job – like coaching by colleagues or supervisors, quality circles, job-rotation, Learning by observation, etc.) (see also Cortina et al. 2003).

already existing knowledge are quite important – e. g. via continuous improvement programs. Apart from characteristic differences (e.g. between the sectors or certain types of enterprises) we found three predominant basic modes of vocational education and training in the sample – in that ranking:

- Internal training on the job and learning by doing,
- External recruitment of key workers on the external labour market followed by an internal phase of training on the job
- cooperative further training with other institutions and companies.

7. Outlook: Long-term jeopardizing of transformative capabilities

We have outlined above that at the moment on the basis of our data it's hardly possible to predict a general trend regarding the skill level in the low-tech segment. Neither a definite trend towards a 'de-skilling' of the work-force can be reported, nor a clear tendency towards an enhancement of the skill-level. But despite lacking a consistent trend regarding skills and qualifications in the investigated low tech companies the résumé has to be drawn, that in the regular workforce there is a considerable underdeveloped potential in low-tech firms to improve the knowledge base of their work force by strategic training and qualification and participative work organisation. Our low tech companies seem to follow more a policy of **muddling through** than a systematic and foresighted personnel policy. This risk of endangering their transformative capabilities in the long run seems to be aggravated additionally by some current socioeconomic tendencies. Mainly three **actual or future problem areas** regarding personnel policy are reported by the investigated low tech companies:

1. General deficits in the labour market supply
2. Longterm conservation of the experienced personnels´ know how as a solution for the generation transition problem
3. bad image of factory work and of low tech companies together with a high competition on the labour market by (big) companies of high wage sectors

(1) General deficits in the labour market supply:

Finally, **recruitment problems** are common also for the investigated low-tech companies. Many cases of our sample – especially from the metal working sector and the paper industry - reported serious problems to recruit adequately skilled workers. This is interesting from a policy perspective as well, as political strategies and labour-market policies are mainly based on the assumption, that this problem is of relevance solely for the high-tech

sector. On the contrary on a national level foremost **labour market policy** and particularly policies regarding the system of vocational training play a crucial role.

Reasons for the lack of trained people in the low-tech sector seem to be on the one hand national education systems, which do not provide even a proper basic education (i.e. in Lithuania). On the other hand, recruitment difficulties occur, when there is a special demand for distinct vocations (i.e. smiths, foundry workers, paper makers), which is in spite of unemployment not provided by the labour market in the requested quantity and quality. In several companies there occurred namely serious difficulties to find workers with an adequate qualification level.

In the case of an Italian manufacturer of car wheels, the company was obliged to buy some services from external companies because of a severe lack of skilled workers, as the workers play a crucial role in their production process.

Because of such difficulties in getting adaquate labour an Irish furniture firm with about 50 employees participated in an EU funded ADAPT project. The impetus to become involved in this project arose as a result of two main changes in the wider environment that had begun to pose significant challenges for the firm and the furniture industry as a whole. First, competition from furniture firms in other countries was becoming increasingly aggressive particularly in relation to price. Second, new employment opportunities in high tech firms in close proximity to the company were offering increasingly attractive pay and additional benefits that made it difficult to recruit labour. Alongside this, the training regime in existence in furniture firm at that time – an on the job four year apprenticeship – was considered by potential trainees as too long and unattractive. All of these features conspired to make employment in what was perceived as a low skill, low wage traditional manufacturing industry very unattractive. Moreover, due to the increased competitive pressures from firms based in low wage cost countries, an increase in pay to entice recruitment to the firm could not be sanctioned, as it was perceived that sales would not be able to expand sufficiently to generate the extra finance needed. Although the company could not hope to compete for workers on the basis of pay or additional benefits, it believed that it could compete on the basis of the quality and type of training that would be developed for its employees partly by making the employees more employable but also by making their work more interesting. Furthermore, upskilling was seen not so much as an optional extra for the company but as a vital aspect of its survival prospects and future growth. Therefore the company focused specifically on the specific training and skills needs of its craft workers, and more generally on the development of ICT and systems capability within the organisation.

Furthermore, these recruitment problems are in a certain way different and more far reaching than the classical well-known problem of a ‘simple’ lack of skilled workers, resulting from an underestimation of its demand. An actual problem, which will be aggravated in the future because of technological and orgnisational innovations in some low tech companies, could be, that the vocations and the curricula, provided by the public education systems, will no longer correspond to the actual requirements of the industry and their modern production processes anymore – i.e. paper-makers today don’t need so much haptical skills as in the past, but much more technical skills and hybrid qualifications (of me-

chanics, electronics, hydraulics etc.) to run modern paper-machines. Many classical skills of the papermaker such as the measurement of the paper quality are no more required, as these tasks are done automatically by the machinery. Vice versa, as the mechanical and electrical parts of the work process grow in importance, new skills, such as the operating of computer-controlled machines, are required as well. However, so far there exists no vocational training resp. a vocation, which corresponds to these new requirements regarding such hybrid qualifications incorporating a mixture of sector specific, metal working, electronical and hydraulics skills as well as ICT competences. Also in the metal working sector similar trends towards new hybrid types of qualification profiles can be identified, which were seen as recruitment constraints.

(2) The Generation transition problem - Longterm conservation of experienced personnel and of their know how:

As we have presented above much of the knowledge of the production process possessed by the shop floor workers has been accrued through years of experience within many low tech companies. This knowledge is acquired through on-the-job trial-and-error experiences in combination with short distances on the shop floor. The knowledge and experiences, formal as well as informal, of the work methods that the senior shop floor staff possess is very valuable to the company. However, in many cases the investigated low tech companies lack a strategy for the protection and preservation of this knowledge inherent in the individual employees. Consequently these non-standardised skills and qualifications and highly personal abilities of individuals are a source of weakness of such kind of companies. In a certain sense they are rather dependent on their workforce and its practical knowledge, which is strongly related to the actual workers as it can hardly be documented. One of the biggest challenges facing low tech firms in that perspective is the generational change, from workers heading to retirement and new, younger workers coming in. Experienced workers going into retirement represent a “traumatic” change for these companies, since most of their knowledge was learned on-the-job and is not very easily transferred to younger workers. Hence workers who leave the company cannot easily be replaced. The companies react to this restrictions with a specific personnel policy. In order to avoid such problems many companies employ certain strategies to tie the workers to the company – e.g. by a strong specialisation of work tasks or internal career options.

This kind of problems was mentioned at a Swedish furniture manufacturer with 100 employees. The company predicts a forthcoming change of generations of personnel, which entails the risk of loosing valuable competence and knowledge residing in its employees. It is believed to be impossible to embody and materialize this knowledge and experience into the machine equipment, as many work stations in the production are highly handicraft dependent. Adding to the problem is the fact that several of the trades within the production are difficult to recruit. Formal education is scarce within many of the professions and instead the company must provide much of the training and knowledge. Some collaboration

with the local employment service agency is taking place: The employment service offers one-year courses where new staff can receive the basic training and knowledge. Then the company uses apprenticeship systems to further educate new recruits.

(3) Bad image of factory work and of low tech companies – increased by a competition on the labour market by (big) companies of high wage sectors:

One further specific problem for low tech companies are prestige and image problems. Many low tech firms find it difficult to recruit a local production/operative workforce. The reason is that a lot of local labour do not want to work in factories anymore, and those that do want to work in the sector are oftentimes not suitable and prone to discipline problems. The popularity and interest in these training activities is decreasing as they generally take several years to fully master and they impose unattractive work tasks in the low tech industry. Also, there is often competition in the regions for persons with these skills. Additionally, some companies recognise limitations in available manpower that comes with being situated in a smaller community and not in a bigger city. Some companies face substantial problems in recruiting qualified personnel especially in the field of skilled and semi-skilled workers because of the competition for qualified personnel in the area by big multinational companies (e.g. from the automotive engineering and ancillary industry).

Due to the lack of suitable local labour, at the Irish furniture producer for example at present, half of the production personnel are Lithuanian or Romanian. In particular, the firm tries to recruit people who have worked in joineries or other wood working trades. The company works closely with a factory in Romania and recruits staff from them for the polishing shop. Actually, most of the furniture factories in the Monaghan area are now employing a certain percentage of foreign workers.

Conclusion: These personnel gaps also often have to be compensated by intensified intra-company vocational training measures and qualification programmes. This is also due to the fact, that an enhancement of transformative capabilities and an improvement of innovation potentials in LMT firms will only take place, if there occur systematic and comprehensive improvements of the work force and the used qualifications and skills.

Finally, our empirical results on established work-force strategies in low tech firms tell us, that on a national level foremost **labour market policy** and particularly policies regarding the system of vocational training play a crucial role in the survival of low medium tech companies in our high-wage and high-cost countries.

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