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Knowledge in Societal Development: The Case of Low-Tech Industries

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Abstract

The paper refers to the ongoing discussion on the current societal change termed as the emerging knowledge society. In this discourse long term growth, competitive advantages on the world market and employment effects are primarily perceived in high-tech sectors, which are regarded as knowledge-intensive. According to this perspective the question as to the future of industrial sectors and companies that produce mature and conventional standard products is not raised at all. Such industrial sectors are generally regarded as "low-tech" and are deemed as being beset with more or less explicitly negative locational conditions. However, there are a number of convincing examples of sectors and companies that have been successfully manufacturing low tech products in advanced countries. And there are also convincing examples of industrial districts based on mature technologies which show a remarkable degree of prosperity. This then is the starting point of the arguments in the paper presented: First of all, the widely held view that knowledge is clearly measurable will be reviewed. Then, the concept of knowledge will be discussed working out the specific features of the knowledge which is relevant to the low-tech sector. The specific knowledge base of low-tech companies will be characterized as “practical knowledge”. Subsequently, the reorganization measures taken by low-tech companies in order to use and develop their specific knowledge will be shown. In the conclusion of this paper, the findings will be summarized and it will be asked for the developmental future of low-tech industries in the context of the ongoing societal change.

Zusammenfassung

Die Argumentation des Papiers bezieht sich auf die sozialwissenschaftliche Debatte über den gegenwärtigen gesellschaftlichen Wandel, der vielfach als die Entwicklung zu einer Wissensgesellschaft bezeichnet wird. In dieser Debatte werden Wachstumschancen und die Entstehung neuer Arbeitsplätze wie generell für Unternehmen Wettbewerbsvorteile auf dem Weltmarkt nur im High-tech Sektor gesehen, der auch als wissensintensiver Wirtschaftszweig betrachtet wird. Wirtschaftszweige jedoch, die alte, konventionelle und standardisierte Produkte herstellen, haben in dieser Perspektive in den entwickelten Ländern nur wenig Entwicklungschancen. Solchen auch als „Low-tech“ zu bezeichnenden Sektoren und Unternehmen werden in den entwickelten Ländern nurmehr sehr ungünstige Standortbedingungen eingeräumt. Jedoch ist unübersehbar, dass es eine ganze Reihe solcher Unternehmen gibt, die sehr erfolgreich in entwickelten Ländern produzieren. Zudem existieren überzeugende Beispiele für prosperierende Regionen, deren industrielle Basis alte und traditionelle Technologien umfasst. An diese Befunde knüpft die Argumentation des vorliegenden Papiers an: Erstens wird die vorherrschende Meinung, wonach Wissen eindeutig messbar sei, kritisch diskutiert. Zweitens wird der vorherrschende Wissensbegriff diskutiert und es werden die Merkmale jener Wissensform herausgearbeitet, die als typisch für den Low-tech Sektor angesehen werden können. Dieses spezifische Wissen wird als „praktisches“ Wissen begriffen. Anschließend werden Reorganisationsmaßnahmen von Low-tech Unternehmen skizziert, die auf die Mobilisierung dieses praktischen Wissens zielen. Abschließend werden einige Thesen zur Zukunft des Low-tech Sektors im Kontext des gegenwärtigen sozialen und ökonomischen Wandels formuliert.

Hartmut Hirsch-Kreinsen

Knowledge in Societal Development: The Case of Low-Tech Industries[1]

1. The emerging importance of knowledge

Ongoing societal change in nearly all modern societies is generally seen in the context of an emerging "Knowledge Society" (cf. Drucker 1994; Stehr 1994; Willke 1998) or "Learning Economy" (cf. Lundvall/Borras 1997). These arguments suggest that modern organizations and societies are currently undergoing a fundamental change process, characterized by an enhanced significance of knowledge as a productive force and asset. Continual innovation is seen as a decisive determinant of economic and social development, accompanied by a restructuring of work processes and organization, with knowledge handling – knowledge generation, diffusion and utilization – becoming a core characteristic. This discourse on the emerging knowledge society describes - beyond any doubt - important tendencies of economic and social development. Following this discourse, completely new patterns of societal structures are emerging, and the economies of industrialized countries in Europe and elsewhere are at least going through two great changes (Carson 1998):

- The first change is that a lot of industrial production is moving from their traditional sites to developing countries; the classic example is the exodus of textiles from the rich world over the past two decades. Quite soon now, many big western companies will have more employees and even customers in developing countries than in developed ones.

- The second change is that, in many industrialized countries, the balance of economic activity is swinging from manufacturing to services. Even in Germany and Japan, which rebuilt so many factories after 1945, manufacturing's share of jobs is now below 30 % as of the GDP. The effect of the shift is increased as manufacturing moves to the developing countries, whose cheap labor gives them a sharp advantage in many of the repetitive tasks required by mass production.

Particularly in western countries, these trends have caused a debate about an ongoing process of "deindustrialization". By the end of the 80s, a lot of American and European experts had come to believe that their countries' industry was being "hollowed out" as many of its basic activities moved to other

[1] Paper to be published in Journal for Mental Changes, Central European Institute for Behavioral Economics, Lublin.

areas (cf. Dertouzos et al. 1989). But all in all, it was not like that. A change is happening, but it is not simply a destructive change. Rather the industry of many countries is reorganizing itself and changing its structure and position in a new economic environment. The result is that many industries are not only still located in their former home countries, but they are also very competitive and successful on the world market.

The main feature of this change process are intensified innovation activities of many companies which are based on the growing importance and utilization of knowledge and knowledge work. To mobilize knowledge and experience, companies have to introduce specific organization and innovation strategies. These strategies are mainly aimed at changing their traditional organizational and personnel structures as well as their conventional style of utilizing technologies. On the level of work organization, more indirect forms of coordination are necessary alongside the conventional, more direct forms of bureaucratic and hierarchical control and coordination. This increases the importance of the employees' commitment, motivation and initiative, especially in new forms of work organizations like group work. The participative use of information technologies, the greater impact of organizational culture and the increased importance of inter-organizational production networks are also indicators for the change process of industrial structures.

Following empirical evidence, this holds even true for industrial sectors, which can be termed as "low-tech", producing mature and simple products like furniture, clothing or light bulbs (cf. The Economist 1998; Maskell 1998). These facts are surprising. Since in the public discourse on the emerging knowledge society there is a firm belief that the high-potential and growth sectors are to be found among the industrial sectors, which are, par force, engaged in innovative technologies and intensive research and development. In other words: "high-tech" industries hold the key to the future. And these are regarded as knowledge-intensive sectors whereas the so called low-tech sectors are usually regarded as little knowledge-based without a real future in many old industrialized countries. Only the high-tech sectors promise chances for development, and therefore, so the argument continues, it makes sense that the economic and technological policymakers should favor them.

This argument simply overlooks that in all industrialized countries there still is a relatively large sector of low-tech industry, in manufacturing as well as in service sectors. This holds true for the old industrialized countries of Western Europe and particularly for the "following" countries of Middle and Eastern Europe with their basis of traditional and mature industries. An indicator of the importance of the low-tech sector in Europe is the well-known OECD classification of industrial sectors based on the concept of R&D intensity, i. e the ratio of internal R&D to output in the industry concerned (Hatzichronoglou 1997). Industries with a ratio of R&D to gross product, or value added, of more than four percent were classified as

high-tech. Those between one and four percent were medium-tech, and those less than one percent were low-tech. The latter sector includes such activities as food processing, mechanical engineering, wood products, retail distribution, social and community services etc.. According to the OECD Inter-Sectoral DataBase (OECD 1997), in the second half of the 1990s, value added in low tech industries, as a share of all manufacturing, ranged in Western Europe from 50 % (Sweden) to nearly 75 % (Belgium). Similarly, the average EU-wide employment in low-tech industries as a share of total manufacturing employment was 55 % in the mid-1990s. With the inclusion of a range of service sectors with little R&D effort, the inevitable conclusion is that European economies, are dominated by purportedly low-tech sectors and activities. This in fact holds true for nearly all European economies even those of Central Europe. A range of studies and indicators show that there is no clear-cut relationship between this low-tech status and low innovation rates. The relative size of these sectors by itself suggests the importance of understanding their innovation-related dynamics. In addition, it can be claimed that present patterns of economic growth and structural change and the potential for future growth involve these sectors to a degree that goes far beyond the naïve claims of the widely used high-tech based view of economic growth.

In fact, major aspects of present structural change in advanced economies happen outside the realm of high-tech industries. As the results of empirical studies show, these low-tech sectors have potential for development and for laying the foundation of growth and need – especially in terms of employment prospects – to be taken into consideration (cf. Laestadius 1995; The Economist 1998; 2001; Schmierl 2000; Hirsch-Kreinsen 2000). Empirical studies prove furthermore, these are industries of high innovative capability that offer prospects for rapid technological change (cf. Maskell 1998; Laestadius 1999). And finally, low-tech products and companies are very often a crucial precondition for the innovativeness of whole value chains and for the design, fabrication and application of high-tech products of various kinds (cf. Kremer 1993; Cohen 1997).

This then is the starting point of the following arguments: First of all, the widely held view that knowledge is clearly measurable will be reviewed. Then, the concept of knowledge will be discussed working out the specific features of the knowledge which is relevant to the low-tech sector. Subsequently, the reorganization measures taken by low-tech companies in order to use and develop their specific knowledge will be shown. In the conclusion of this paper, the findings will be summarized and it will be asked for the developmental future of low-tech industries in the context of the ongoing societal change.

The following argumentation is based, firstly, on results of an empirical research project on case studies in 16 low-tech companies in Germany. Their products are, for instance, simple gaskets, plug connec-

tions, fuses, office material, corrugated paper boxes, standard kitchen furniture, and bath tubs.[2] Secondly, the arguments are based on groundwork for an international research project which deals with the developmental chances of low-tech industries in Europe.[3]

2. The black box called knowledge

Many widely used concepts such as "high-tech" and "low-tech", and their derivatives owe their origins to concepts and interpretations of economic growth that were developed during the period 1945-1960. This holds particularly true for the above-mentioned OECD technology indicators. In this framework, science and scientific knowledge are a core focus: Research and development (R&D) input as a share of some industrial activity measure (such as sales or value added) has, for a long time, been used as the most important indicator of technology levels. High-tech firms regarded as knowledge-intensive are quite simply those which spend a large share of their resources on R&D; low-tech firms i.e. those utilizing little knowledge are those which do not. Following the OECD taxonomy, the indicators define technology intensity as follows (cf. OECD 1997; Palmberg 2001):

- Industries spending more than 4 % of total output on R&D are classified as high-tech; these industries include, for instance, aerospace, computer technologies and pharmaceuticals.

- Those spending between 1 and 3,9 % are classified as medium-high-tech or medium-low-tech; included here are, for instance, electrical machinery, motor vehicles, mechanical engineering, shipbuilding and petroleum refining.

- The remaining industries with R&D expenditures below 1 % of total sales are categorized as low-tech industries including, for instance, paper and printing, wood and furniture, and foodstuffs.

This perspective is attractively simple - especially for nations and communities that wish to develop knowledge-based economies. However, this view has to be explored very critically.

Firstly, major definitional, conceptual, and analytical questions have to be raised. It can be demonstrated that the above-mentioned indicators of levels of knowledge intensity that are typically used are not robust, in the sense of being consistent across industries. For technology intensity indicators are, in fact, very partial measures of techno-economic dynamics of a sector or the system in which it partakes.

[2] The case studies have been conducted in the years 1997 to 1999 and were funded by the German Federal Ministry of Education and Research (BMBF). For in-depth results of this empirical project, cf. the final report, ed. by Schmierl (2000).

[3] The project „Policy and Innovation in Low-tech" (PILOT) will be promoted for three years from December 1st 2002 by the European Commission. Eleven partners from nine European Countries will participate. The project is coordinated by the Chair of Industrial Sociology (hitherto: Technology and Society) University of Dortmund.

Particularly, their major flaws are related to the fact that they are based on rather one-sided fixation on R&D expenditures as the main indicator of the specific character of an industry and its innovativeness (cf. Palmberg 2001). As a result, they tell little about either the real knowledge intensity in a general sense or about growth prospects. It is further to argue that there are fundamental methodological (especially statistical) flaws, as well as flaws of logic, in high-tech growth models. The indicators can be characterized as uni-dimensional, which can be regarded as being seriously misleading (cf. Laestadius 1999).

Secondly, the character of the specific knowledge created in low-tech industries and of its relevance for the innovative capabilities of individual companies, value chains and regions is overseen. This knowledge can be characterized, as will be shown later, as predominantly "practical" or "application-oriented", distinct from "theoretical" or "scientific" knowledge, and resembling what *Michael Polanyi* (1966) has termed "implicit knowledge" in contrast to "explicit knowledge". Furthermore, there is a general neglect of other major dimensions of knowledge in economic production. The study by *Wendy Faulkner* (1994; also Faulkner/Senker 1995) illustrates this well: It is shown that knowledge used in industrial innovation and production processes has many different dimensions. They may not be reduced on that single indicator of R&D intensity; it is rather a question of conceptualizing "knowledge" considering different dimensions such as: the object of the knowledge in question and the specific character of knowledge (Faulkner 1994: pp. 449). Only a careful analysis of these different dimensions reveals the specific character of industrial production and innovation processes. Moreover, a recent study on the dynamics and characteristics of firms' relations to external repositories of knowledge (Hales 2001), demonstrates that a distinction between knowledge as furnished by external repositories or 'knowledge bases' and the productive competence underpinning firm-level innovation and behaviour is essential for understanding the 'learning processes' of innovating firms. Rather than the concept of 'knowledge intensity', this implies that the relevant driver is 'competence intensity'. This in itself suggests the basic limitation of high-tech, science-driven approaches to understanding industrial processes and innovation.

Fourthly, this raises the question whether it is possible to adequately analyze the specific features of innovation and production processes through a more or less isolated approach to knowledge; since that kind of isolated approach, if only for reasons of method and measurability, focuses the analysis on explicit or codified knowledge. The analysis of work and production structures, where knowledge is used, transferred and generated in its many different forms, seems much more appropriate and is the only way to do justice to the context-bound character of knowledge. The development of knowledge is always bound up with persons, actions and situations, i. e. generally with the context.[4] This means, if you

[4] In this sense, knowledge is to be comprehended as a socially determined phenomenon and should not be mixed

want to reveal the specific type and form of knowledge and its relevance to production and innovation, you have to focus the analysis on its connection with the action and work context in each case. Instructive examples are, for instance, investigations on automated production processes by *Fritz Böhle et al.* (1992), where the relevance of the informal side of work organization and experience-based knowledge involved to the efficiency of highly standardized and automated production processes is worked out in a convincing way. As for the investigation on the seemingly little knowledge-intensive low-tech work processes, one may come to the conclusion that only the analysis of the whole production and work process makes it possible to draw conclusions on the question whether - and if so - which forms of knowledge are really constitutive to them.

In short, there is a definite need to reconsider the prevailing understanding of the dynamics of production and innovation in the present epoch. This appraisal must be based on a thorough understanding of the dynamics of economic change as it unfolds across industries. In other words, the black box called knowledge has to be opened and analyzed seriously. In the following, some preliminary steps will be taken in this direction.

3. Knowledge in low-tech industries

To analyze the specific form of knowledge relevant in low-tech industries, it is, first of all, obvious that we have to fall back on the type of knowledge which is not covered by knowledge indicators, i. e. tacit knowledge. Of course, this concept is only hard to comprehend precisely; it is always being defined in connection with the concept of explicit knowledge, and an abundance of synonyms for it are used within the debate of the sociology of knowledge (cf. Ambrosini/Bowman 2001). Based on Polanyis' epistemological perspective, tacit knowledge can be defined as follows (cf. Lam 2000: pp. 490): Firstly, explicit knowledge can be codified, stored and transferred whereas tacit knowledge is intuitive and unarticulated. Knowledge of this type is action-oriented and has a personal quality that makes it difficult to formalize or communicate. Secondly, explicit knowledge can be generated through logical deduction and acquired by formal study. In contrast, tacit knowledge can only be acquired through practical experience in a specific context, i. e. learning-by-doing. Thirdly, explicit knowledge can be aggregated at a single location, stored in impersonal forms and utilized without the participation of the knowing subject. On the contrary, tacit knowledge is person- and context-bound. It has a distributive character and cannot be easily aggregated. Still following Polanyi, the origin of all human knowledge is based on tacit knowledge generated through individual intuition.

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up with pure data and information (cf. Nonaka 1994: 15; Willke 1998: pp. 6).

If you look at this concept from the - in this case essential - work-process perspective, it becomes clear that tacit knowledge involves “action” and “doing”. It is not a question of “knowing that” but rather of “knowing how”, as already pointed out by Polanyi (1996). A number of conceptual extensions follow from this: Tacit knowledge is closely intertwined with the current work process. It shows a distinctly *practical character*, since it is acquired at work in an inductive and explorative way, i. e. through the above-mentioned learning-by-doing. Furthermore, it is composed of technical skills and sedimented into more or less established work practices and rules. These work practices and rules are not necessarily person-bound, they are rather work norms accepted collectively by the employees. They can show an overpersonal character and can also be explicable.

This touches upon the collective dimension of knowledge, which - due to its cooperative character - must not be ignored when analyzing working processes. It always concerns knowledge which is stored in the rules, procedures, routines and shared norms of a working process as well as the factors which guide the problem-solving activities and patterns of interaction among its members.[5] In this sense, the collective side of knowledge is rather to be found between than within individuals. It can be more or less than the sum of the individuals’ knowledge, depending on the mechanisms that translate individual into collective knowledge (cf. Lam 2000: p. 491).

In order to be able to comprehend these connections in their entirety as for the analysis of working and production processes, the knowledge in question should be called *practical knowledge*. As mentioned above, it is acquired through the ongoing process, trained and transmitted on the basis of learning-by-doing; it shows an individual and a collective dimension. Practical knowledge is, as a rule, not documented or covered officially by work instructions, operation plans and documentation rules. It mainly refers to the informal side of a working process[6] often marked by well-going working methods as well as cooperational and communication patterns, which, however, are not to be found in any official organization chart. They are accepted, carried out and controlled by the employees involved. It is based on collective experience and commonly shared norms on how a working process should take an effective and efficient course. Just as every practitioner knows, this may result in clear differences from the officially and formally planned working organization, which are, nevertheless, absolutely essential as for the workability and innovation ability.

[5] In this sense, the collective dimension of knowledge refers to the phenomenon which is also called “the collective mind“ of organizations (Weick/Roberts, 1991).
[6] In contrast to the formal side of an organization as the planned and officially defined rules system of an organization. It is a generally known fact that the functionability of an organization is based on the interplay of both the formal and the informal side (cf. Mayntz 1966).

However, practical knowledge can be recorded - unofficially - in personal documents and notes. A good example of it is the "black book" in a foreman's trouser pocket where he writes down the experience gained when coping with everyday production problems in order to fall back on it whenever it might be necessary. Another widely known example are the operators of computer-controlled machine tools who operate machines by means of unofficial programs which are often unofficially modified. This modification of the programs allows a fine tuning of the operations so that the production process might be much more efficient than if it was run with the official programs.

Practical knowledge is also marked by the fact that it cannot be clearly separated from explicit and theoretical knowledge. A number of studies on the course of innovation processes in companies have shown[7] that practical knowledge is always marked by double openness: On the one hand, its bearers seem to be able to adapt and to use knowledge acquired scientifically and systematically in order to cope with specific work problems. Practical knowledge is often the precondition for systematic work rules or engineering and technological findings, prototypes and other products. In other words, practical knowledge is in reality closely connected with theoretical knowledge. In this sense, practical knowledge shows high dynamics and potential for development with its bearers proving to be very capable of learning. Thus, the above-mentioned modification of NC programs is just based on the competent and experience-based adaptation of given codified knowledge in the form of the programs developed in the programming department and the logical and syntactic rules of a programming language. Another instructive example, described by *Laestadius* (1995), is the absorption of external R&D results in a company producing anchor cables. It concerns the adjustment of given material parameters to the actual requirements of a forging process whose course is hard to calculate. Obviously, it requires a high degree of practical experience, which the employees are provided with. A third example of this phenomenon are working processes of engineers in construction and development departments. They are ever since especially based on the engineer's skill, i. e. his experience and "instinctive" feeling, enabling him to apply his systematically and scientifically acquired knowledge to the relevant problem and to implement it in order to find solutions (cf. Wengenroth 1999).

On the other hand, however, empirical knowledge can also pass into officially codified knowledge by being recorded in technical documentation and databases. So, the content of the foreman's "black book" can turn into official work instructions and documentation; the operator informs the plannning department about the modifications - which is already common practice in many companies - where they are added to the next official program for the computerized machine tools and stored in the database for

[7] This has been instructively proven by investigation results of very different social-science disciplines such as innovation economics (cf. Nelson/Winter 1982; Faulkner/Senker 1995), sociology of technology (cf. Asdonk et al. 1991) and sociology of knowledge (Nonaka 1994; Nonaka/Takeuchi 1995;Willke 1998).

these programs. In other words, these are processes of knowledge conversion between practical and theoretical knowledge. These conversion procsses can be considered as a central prerequisite for innovations, since in this way new knowledge is created. Nevertheless, these processes are not unproblematic, as already shown in particular by *Nonaka* (1994)[8], and a number of requirements have to be met. Thus, new knowledge can only be generated on condition that the transitions between the many different types of knowledge are made to last and kept free of disturbance.

If we apply these considerations to the specific features of low-tech production, we can start from the assumption that in this industrial sector there will predominate a type of knowledge which comes very close to the outlined features of practical knowledge in a special way. According to *Laestadius* (1995; 1998), this kind of knowledge proves particularly successful for solutions to technical everyday problems and for intelligent variations of well-known problems, e. g:

- the ability to handle daily specific product materials such as developing and processing specific steel alloys in order to prolong the life-cycle of, for instance, machines used in agriculture;
- the know-how and the experience needed to guarantee the smooth running and the improvement of complex production plants used in the manufacturing of gaskets and fuses;
- the mastering of processes and logistics in order to improve the processing flexibility and the market position, aspects that play a prominent role in the making and distribution of kitchen furniture;
- the competence for a customer-specific interpretation of mature products such as anchor cables on the basis of often incomplete information and specification, and for adjusting it, at the same time, with flexibility to the required technical procedures.

In other words: what characterizes the production processes of the low-tech sector is its reliance on knowledge that is created and reproduced through learning-by-doing, empirical trial-and-error, and limited systematic training. Its essence is an intuitively accumulated type of know-how. Experience is gathered while dealing with the material reality of the product and the manufacturing processes. The knowledge of the trade has not primarily been acquired in a theoretical or cognitive way, but may be identified as know-how of a markedly intuitive quality and closely tied to the human resources. It is each individual working for the company that possesses competence, which is only partially available and visible to the outsider in the form of organizational guidelines, objectified information such as technical norms and standards, written directives, documentation material, and databases.

[8] See also in detail Nonaka/Takeuchi (1995).

4. The mobilization of practical knowledge low-tech companies

Asking how low-tech companies mobilize their specific practical knowledge, a broad spectrum of reorganization and innovation strategies can be found in the German companies where case studies have been conducted (cf. Schmierl 2000). They range from a far-reaching technical-organizational restructuring of the entire production process to partial and gradual steps of reorganizing certain functions. Fundamentally, the organization must make it possible to continuously make use of the practical knowledge available and to permanently develop and adjust it in response to new requirements. For low-tech companies, this means breaking with the “Tayloristic” structures they had grown fond of, characterized by a strictly-defined division of labor, highly repetitive tasks and the use of mostly semiskilled or even unskilled workers. For it was exactly those structures which convinced workers to hide their knowledge of the trade or to use it for little innovations only unofficially in order to gain more freedom. Therefore, it seems essential that reorganization measures aim at removing blockades by redefining job profiles, cooperation and process structures. All in all, there have been efforts in the companies investigated to create organizational forms in order to remove this blockade allowing much more than before an effective mobilization of existent knowledge and its continuous development.

According to the existing literature, this basically requires organizational structures enabling intensive interaction and communication between the employees involved and, consequently, a continuous exchange of knowledge as well as collective learning processes. Cross-functional and self-organizing teams, which show a high degree of functional redundancy and low specification of the employees (cf. Aoki 1988; Nonaka 1994; Leonard-Barton 1995; Nonaka/Takeuchi 1995), are considered to be one central element of such organizational forms. The argument is that cross-functional teams integrate and synthesize knowledge across different areas of expertise serving as a bridge between the individual and the organization. It is at the team level at the intersection between horizontal and vertical flows of knowledge, where the greatest of interaction, learning and knowledge diffusion can take place (Lam 2000: 498). Of course, a lot of additional organizational conditions are necessary, if knowledge mobilization is to work properly. What is pointed out in particular is the successful and consistent integration of the teams into organizational basic structures, ensuring orientation and stability, and the existence of a company culture conducive to knowledge.

As the results of the case studies show the reorganization measures of the companies aim at the essentials of such knowledge-conducive organizational forms. In most cases, this means, of course, a far-reaching break with present "Tayloristic" structures so that the reorganization process often turns out to be long, laborious and risky.

4.1 Teamwork and Qualifying Measures

The main approach towards mobilizing practical knowledge and experience is that of reorganizing tasks and qualifying the staff. Such measures play a central role in the spectrum of reorganization strategies of almost all companies investigated. They aim at enabling staff to develop autonomous competence for rationalization and innovation and to react flexibly to changing market situations. Companies pursue this objective by a variety of means which result in qualitative promotion, an increase in autonomy, and the improvement of human resources motivation. All measures taken are based on human resource-oriented management concepts, well known since the Lean Production debate in the early 90s: the measures, moreover, are tailor-cut to meet the specific needs of low-tech producers.

In the companies, one finds, respectively, various forms of teamwork as the central means of reorganization which ultimately leads to the staff's active participation in a continuous process of rationalization. The spectrum of measures taken is broad: They may take the form of an implementation of teams supervising the production process, such as the setting up of quality assurance groups. They may also be far-reaching, such as structural changes of task or process organization through separating planning and operational tasks in teams that are given a high level of autonomy in planning.

One example of teams supervising the production process is that of a company making gaskets; it is influenced by the principles of the Japanese Kaizen. The measure runs by the name of „Growtth" (i.e. „get rid of waste through team harmony"). Within a period of time, the teams that are formed to work on specific rationalization problems and projects. In turn, the management defines the compass and the concrete objectives of each Growtth-project. The team fulfills the task within three or four days, and the improvements suggested are realized immediately. The team members belong to all levels of the company hierarchy; customer representatives or distributors may be included in the team as well. How the solution is found, how change is brought about and implemented is left to the team members. On the one hand, this measure aims at mobilizing the practical knowledge of the staff involved by establishing open and self organized group situations. On the other hand, this situation is regarded as a precondition to induce learn processes and to improve the knowledge of the staff.

However, the introduction of teamwork creates the desired effects on mobilization of knowledge only if it is accompanied and supported by an appropriate framework, the other reorganizational measure whose importance is often overlooked. This means, first, that a business turns to systematically rewarding and thus to remunerating the performance of the team as a collective and its results rather than the individual. Second, a number of businesses have been moving away from inflexible working hours, as, for

instance, set shifts and the concept of overtime. What is used instead is a time corridor which regulates the working hours according to the order position. Third, objectives can be reached by the introduction of teamwork only if the personnel is systematically enabled to use the potential of the new group structures. This requires professional development via qualifying measures.

In addition, the companies showed attempts at combining the outlined work-organizational adjustments with a change of management roles and managerial style ensuring hierarchically the transfer of competence to the workshop. But, given the volatile nature of this issue in terms of company policy, it is hard to say on the basis of the case studies to what extent such changes are really effective and being pursued. At least, however, you can often hear from the management representatives those formulas for necessary changes, such as "coaching" or "the manager as service provider to the team", which are characterizing current management debates. But if these formulas are not accompanied by real changes, conflicts and counterproductive effects cannot be excluded. In one of the companies investigated, some older foremen had to be transferred from production, since they were not willing to accept the working teams' increase in competence. Their "overnight"-replacement was necessary to avoid conflicts.

One exemplary company which introduced teams effecting structural change and which took into account all the above-mentioned aspects is that of a supplier to the automotive industry that mass-produces highly standardized plastic parts. The company established several teams each of which is in charge of the full production cycle of one of two products. The teams possesses all the resources required; in turn, the teams bear full responsibility for cost effectiveness, time completion and customer satisfaction. Tasks concerning organization and discipline are carried out by elected team coordinators. What complements this work organization is a wage system designed for the collective team processes: each member of a team receives the same basic salary on top of which the team is paid an incentive bonus dependent on quality and productivity. This bonus system aims at each team's ambition to be cost-effective through continuous rationalization procedures. 50 % of the costs reduced are distributed among the team members as monthly premiums. In principle, the system allows „negative premiums" as well. An increase in costs that can be attributed to one team leads to wage reduction for each team member.

Working hours are flexible from Sunday evening to Saturday evening; there are no fixed core hours. Up to 100 hours can be „collected and saved". A week's work load may range from 18 to 48 hours; the concept of overtime no longer exists. Even though this means there is no compensation for overtime or weekends, the staff receive a guaranteed monthly salary. In addition, the works council negotiated a company agreement which guarantees safe employment for a four-year period. At the time the case study was undertaken, this agreement was intended to be renewed each year.

According to the statements of company managers, the change of the working structures and the activating process of the knowledge of the staff have been leading to considerable rationalization and innovation. Although they cannot always be quantified or separated from the effects of other measures taken at the same time, the interviewees often mentioned that performance, quality and flexibility improved visibly. In one of the companies, in which conductor sheets were produced, the effects on the output could be quantified: Within a period of three years, the rate of defective products could be cut by 50 %, the production time by more than 75 %. Those results are remarkable, last but not least, because this was in an area of low-tech production including manual assembly; its workers were for the greater part unskilled women who are traditionally not considered to hold great potential for innovation.

4.2 Continuous Innovation of Production Processes

The technical and organizational modernization of production processes in their entirety makes for another essential cluster of measures taken in the course of reorganization strategies. It consists, for instance, of gradually changing of the process organization; and it is turning away from traditionally functional organization structures in favor of a production- and process-oriented form of organization, of standardizing and adjusting the spectrum of products, in order to simplify the production cycle. In almost all of the companies investigated, it was not thought possible to successfully restructure the organization of the processes and the production cycle without mobilizing the employees' knowledge and experience. Thus, the management of a maker of kitchen furniture declares that the professional development of staff is the key to the rationalization aimed at by simplifying products and optimizing material flow. In turn, they have got the chance to learn and to improve their practical knowledge by running the process.

This can clearly be seen, if one looks at the example of a switch-box manufacturer. Here the hitherto functional organization of production processes was replaced by a process-oriented form of production classified by type of order and product clusters. At the basis of this structure, there are newly-defined segments of the production process. Thereby the management intends to realize flexible production cycles that can adjust to variable demand. However, the reorganization of the processes alone turned out to not suffice in reaching this aim. Changing the work organization was just as essential. In contrast to the past situation, each group working on an individual segment was given relatively free play in planning by reintegrating planning and execution. First and foremost this meant that scheduling was decentralized, in order to put the managerial and executive responsibility for an order into „one hand". Besides, the company set up teams in charge of problem-solving and continuous optimization within their areas. The employee-centered approach resulted in frequently changed and reorganized production cycles. They were modified, to a high degree independently, by the workers themselves and so adjusted to meet the demands of flexible process organization.

Apart from the changes in process organization, one can detect reorganizational measures aiming at the improvement of communication processes. According to the case-study findings, continuous flow of communication is considered to be of utmost importance. It ensures that the particular interest of individual departments which, true to Taylorism, used to be screened off from each other no longer dominate. Interdepartmental objectives may be developed and communicated and operations be streamlined. Reorganizing the flow of communication within the business ultimately aims at improving cooperation between different units, departments and so between different types of practical as well as theoretical knowledge. What this implies in organizational terms, is that departments separated from each other on purely functional grounds are at least partially unified. The above-mentioned introduction of a process-oriented production structure is a classic example. Another example may be described as the attempt at creating closer links between the development and the manufacture of a product. Some businesses, for instance, temporarily set up problem-solving teams from different departments, e.g. from Construction, Quality Assurance and Shop Floor.

In several companies investigated, the close collaboration between different departments is part of an overall strategy to keep all central production units in-house. This, of course, is diametrically opposed to popular management concepts in favor of reducing the product and production range and focusing the company on its so called core competencies. According to the management representatives interviewed, it is the greatest possible control over the means for the creation of value by which know-how and experience can be kept and developed. So, a maker of kitchen furniture follows an „everything-at-one-site“ strategy. This led him to keep a wide product and production range and to reintegrate previously outsourced production units and other departments, such as saw-cutting and treatment of furniture fronts. The management of another business – a manufacturer of simple fuses – subject their decisions concerning relocation and outsourcing to the objective of securing the competence of the business, thus creating the conditions for expansion. This implies that the most important engineering and production units stay within the company and are closely linked to the marketing department. Only those components that must be adapted to meet the demands of different local markets are produced in the respective countries abroad. As the technical director explains, it is by this strategy of concentrating central functions for the creation of value at one site that the company remains competitive also when confronted by low-cost competitors from low-wage countries. This strategy allows the company to react flexibly, to keep high quality standards and to be extremely innovative in further developing their products.

Considering the often incalculable market and competence conditions, there are, of course, hardly to be seen any real “final states” of company organization and process structure in the companies. These

activities - just as the management's view involved - are rather to be considered as an ongoing process, which has to make allowances for the turbulent and hardly calculable external conditions. It is considered to be successful, if, on the one hand, it increases the internal continuity, stability and reliability of the processes and, on the other hand, enables a distinct and flexible orientation towards the market and the customer. In other words: A flexible organization capable of seizing new sales opportunities, and, at the same time, capable of being in control of the resulting continuously growing complexity is to be implemented. According to the findings, this target is a difficult challenge, especially for low-tech producers, since they have to open their highly standardized and, in some cases, even deeply ingrained structures in order to activate hidden knowledge which may be going to waste.

4.3 Increased importance of external cooperation

The reorganization strategies of the companies are no longer concerned with internal affairs only. Similar to those of other branches of industry, they look to external production and market relations. Establishing relations with other companies, organizations and institutions is an activity even low-tech industries cannot do without anymore. It helps in overcoming the limitations of one's own resources and know-how and in developing new and progressive production and innovation potential.

As is the case with a number of branches of industry, vertical cooperation with suppliers and distributors has also been gaining in importance for low-tech manufacturers. Relatively loose and order-dependent connections have been extended and intensified in order to optimize the time for delivery, to reduce storage costs, and, first and foremost, to test and probe the potential for the development of the product mix. The already mentioned maker of kitchen furniture even talked about „a strategic alliance" which he was to enter into with selected distributors for the joint development of product components. In order to make cooperation easier, his business is setting up relations with suppliers in the region whereas relations with distributors from abroad are broken off. The basic reason for this measures is to widen the knowledge base of the company by implementing a continuous flow of information and knowledge to and from the suppliers. This knowledge flow is particularly supported by interaction mechanisms based on the regional proximity of the partners involved.

Relations between the company and its customers are reshaped as well. It becomes increasingly important to cooperate with select customers. This stabilizes customer relations, and integrates customer needs and interests into the product development and design. Following this trend that can be observed in many branches of industry and that has been termed „production on demand" or „mass customization" (cf. Rautenstrauch et al. 2002), it seems to be an opportunity for manufacturers of low-tech products as well. It enables them to take innovative measures in a clearly defined, and goal-oriented way, to escape some pressure of competition, and to develop new market potential. The manufacturers of low-

tech products thus reshape their relations with customers by interlocking communication and adjustment processes.

The producer of gaskets, for instance, makes customers members of his „Growtth teams“, at times, as I mentioned earlier in this paper. By this, he seeks to solve problems of quality assurance and delivery time. Another approach includes the producer's intention to change the traditional practices in distribution and internal communication by creating a new space for customer interference and feedback. He strives for cross-border and inter-organizational cooperation which, to quote the management, is to „enable a customer relationship that is based on partnership“. Both partners are to exchange know-how and service. In order to underline the importance of this form of cooperation, the companies interviewed frequently talk of „systemic partnership“. Even those manufacturers of low-tech products at the end of the production chain producing goods for an anonymous market, attempt to collect information on the profiles of their customers and to establish market relations with them. The manufacturer of fuses who used to cater for retail is a classic example. In order to learn more about market conditions and customer interests, he has been trying to avoid the retailers, such as wholesalers of building materials; instead, he has been seeking business relations with the customers directly, in his case, crafts- and handymen. By this, the management hopes to gather information on the practicability of the products and thus ideas for their further development.

Examples of horizontal cooperation with direct or indirect competitors were rare in Germany, however. Interviews with the management showed that such strategies were not excluded in theory. They too were considered to be an option by which to open the product spectrum and to join forces in marketing activities in order to face competitors. Yet, attempts at cooperation existed only with manufacturers of like products and product components. The producer of faucets included in this study is a case in point. Together with another manufacturers, he pushed the development of a completely new product which is being marketed jointly in North-America. Wider, closer and long-lasting cooperations with competitors like those documented in literature on the "Third Italy", well-known in industrial and regional economics, or the furniture industry in Flanders (cf. Pyke/Sengeberger 1992; Maskell 1998), could not be found in the companies investigated.[9]

It should be noted, however, that horizontal cooperation is of a very delicate nature. Latent fear of losing know-how to potential competitors exists at the management level of many businesses and proves to be a great obstacle to cooperation. As long as companies cannot rule out the possibility of threatening situations to arise they tend to do without cooperative business relations to other companies. Besides,

[9] This, of course, refers to a specific German feature, since not only the present findings have shown that strong horizontal cooperations are relatively rare in German industry (cf. Hellmer et al. 1999; Reindl 1999).

sales interest of each of the partners cooperating determine how close such ties may be. Or, in the words of a manager: „When it comes to wooing customers it is each man for himself."

5. The future of low-tech sectors

To summarize the arguments: It appears that the intelligent and successful production of low-tech products presupposes a specific practical knowledge available to the respective company. Its basis are the skills, experiences and the know-how of those employed in the company which is generated and continuously reproduced in the work process. This result corresponds with the recent revival of the debate in the social sciences, dealing with the growing importance of knowledge-intensive work and the need for organizations to learn and to develop know-how. These aspects are generally regarded as characteristics of an emerging knowledge-oriented society. As already stressed at the beginning, these arguments describe unpredictable tendencies of social development. The described reorganization measures of the low-tech companies without any doubt fit this perspective. Not only do they make intensive use of the knowledge available to them; they also develop it and restructure their organization accordingly.

This means that knowledge and knowledge-based innovation strategies cannot be regarded as features of expanding and new sectors, such as professionalized services and software production. Without a doubt, these sectors must be regarded as markedly knowledge-based, since they are immediately dependent on the use of explicit knowledge. As the findings presented here show, phenomena relevant to the debate may also be found when one studies other types of knowledge in industrial core industries – industries that from the point of view of an emerging knowledge-based society are outdated and little future-oriented. Those sectors are not marked by gradual erosion. Instead, they will reposition themselves in the context of socio-economic change. In spite of globalization and growing competition, prospects are good especially on the markets for mature products. The reason is the specific practical knowledge low-tech companies are provided with, which, in many cases, can hardly be used by potential competitors. For this knowledge, as mentioned above, can be deeply embedded in the social system of a company and its local environment, which makes it hardly transferable and accessible to competitors for the production of similar products; since it would require a reconstruction of the unique amalgamation of the company-specific know-how, the skills of the employed, informal organization structures and probably its regionalized capabilities (cf. Maskell 1998). Obviously, this applies - paradoxically - to standardized products which can considered to be easy to imitate.

These arguments lead to a specific understanding of the restructuring of the economic landscape of Europe at the beginning of the 21st century. This change does not appear as a wholesale structural

replacement of “old” sectors with “new” ones, or as substitution of “old” technologies with “new” ones. It evolves as a restructuring of sectoral and technological systems, transformed more from within than from without. This change process is not dominated by industrial activities where competitive advantage, capability formation and economic change are constituted by frontline technological knowledge. Rather, it is dominated by what are often wrongly termed low- and medium-tech industries. There are many who argue that, since high-tech industries and "knowledge-intensive" industries are one and the same, the economic health of Europe depends simply on the capacity to create and nurture so-called "high-technology" industries. These industries, particularly the information technology and telecommunications (ICT) cluster, are regarded as the bearers of growth, employment and trade success in the future. The policy conclusion tends to be that innovation policy, technology policy and, indeed, economic policy more generally ought to be focussed primarily on the creation of ICT industries.

Following the above outlined findings, it can be supposed that this type of analysis, and the analytical and policy conclusions that result, are deeply flawed. The concepts and categories used to describe allegedly high-tech, knowledge-intensive industries are seriously oversimplified, lacking empirical support, and conceptually naive. Rather, it can be emphasized that:

- The innovation systems of Europe and indeed of most industrialized countries are strongly influenced by low-tech industries.

- The knowledge bases of these industries are deep, complex and systemic. They use engineering and scientific knowledge and are closely integrated with the science and technology infrastructure. The mere fact that they do not do much internal R&D says nothing at all about knowledge intensity or their contribution to the knowledge economy.

- They are very often embedded in specific regional structures and are part of regional company networks that differ from country to country and are part of specific national and regional innovation systems.

Furthermore, the involvement of low-tech products and companies is frequently a core precondition both for the innovativeness of value chains - or production systems - and for the design, fabrication and use of a range of high-tech products. Collaboration and networking between companies of different industries at regional, national, as well as trans-national levels, are increasingly becoming important determinants of the innovativeness and competitiveness of individual companies. These value chains, filières or clusters include low-tech companies not just as tiered participants in supply chains or as more-or-less passive receptors of technologically advanced machinery and equipment developed independently of

user specifities. In addition, the dynamics and efficiency of value chains may be crucially dependent on the reliability and effectiveness, the capabilities and specific knowledge of their low-tech partners and on their integration into innovation processes in other firms in the cluster, whether low-tech or high-tech. It has to be emphasized that the focus on low-tech firms as parts of wider value chains implies an immediate inclusion of service functions, whether supplied by independently organized service firms, as secondary industrial activities of other firms or through intra-firm production of ancillary services.

This focus on the contribution of low-tech industries for the innovativeness for industry in general is extremely important in a political perspective, both for the potential of effectively formulating national and regional innovation policies and for developing a proper foundation for the identification of the overall growth and performance possibilities of the European economy. The development of the low-tech sectors is of great importance for both 'old' industrialized and more recent 'high-tech' economic countries and regions. Following the arguments above, the high-tech perspective of many economies is based on the presence and dynamic interaction of reliable 'low-tech' functions and processes. This holds particularly true for value chains which have an increasingly transnational, and global, character and can be regarded as one of the driving forces of the economic development. This aspect is of outstanding importance for the future development of the Central European countries, since many low-tech processes are located there and they are more and more isntegrated into the internationalized value chains. But also in a general perspective, their development is largely based on the competitive and innovative capabilities of low-tech industries.

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