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Knowledge-Intensive Entrepreneurship in Low-Tech Sectors

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Abstract

In the context of the discussion on the future of knowledge-based societies knowledge-intensive entrepreneurship (KIE) is being regarded as a central transformative mechanism to push this development. So far, the debate on KIE has mainly focused on new technology-based firms or academic start-ups in high-tech sectors. To date, little attention has been paid to sectors that do not conduct R&D and that can therefore be characterized as non-research intensive or ?low-tech?. In this paper the question will be posed what KIE can mean in the context of low-tech sectors and which specific characteristics it has. It will be shown that low-tech sectors basically offer only very limited opportunities for KIE activities due to their strong path-dependency. However, based on a detailed empirical analysis specific conditions and mechanisms of KIE processes in low-tech sectors can be pointed out. An analytical model of KIE in low-tech sectors will be outlined and preliminary empirical findings will be presented.

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1. Introduction

The starting point of this paper is the ongoing scientific discussion on knowledge-intensive entrepreneurship (KIE) (cf. Audretsch et al., 2002; Malerba, 2010; Malerba and McKelvey, 2010). With reference to this discussion, the concept of entrepreneurship includes the following well-known dimensions: First, the term entrepreneurship is intimately linked to innovation and economic change, entrepreneuring is regarded as an activity fraught with uncertainty that aims at creating something new of economic value: a technology, a product, an organization, a market. In other words, the economic value of entrepreneurship depends on the economic value of the resulting innovation. Second, according to Schumpeter, the term entrepreneurship implies the introduction of “new combinations”, i.e. of innovative activities that are not only new to the firm-specific knowledge but also new to the sectoral knowledge base or technology field; in other words, innovation have a strong impact on existing economic and technological structures. Third, entrepreneurship is defined as a process. It includes all aspects such as decisions, perceptions, organizational steps, feedback loops etc. of an innovation process. Fourth, the term knowledge-intensity points to the fact that entrepreneurial activity is significantly based on existing and new knowledge, in particular it is strongly oriented towards the utilization of scientifically and technologically created knowledge. Hence, the term KIE is narrowly linked to the discourse on the growing significance of knowledge for societal development and the emerging “knowledge economy”. Fifth, KIE is mostly characterized by the foundations of new companies, i.e. start-ups or spin-offs. However, entrepreneurial activities within existing firms or other established organizations are not excluded; this situation is termed as corporate entrepreneurship. Sixth, this concept refers to innovation system approaches, i.e. the cooperation of KIE actors with “neighbouring” and “supportive” organisations and firms. Their embeddedness in the institutionalised conditions of a sectoral innovation system and beyond are regarded as crucial prerequisites for economic success.

The concept of KIE refers to knowledge as the very basis of all entrepreneurial activities. Knowledge-intensive activities are based not only on the use of existing knowledge but also on the integration and coordination of different knowledge assets and the creation of new knowledge. Thus it is a constitutive feature of knowledge-intensive processes that they call for more than the sectoral knowledge base and the already existing and established procedural and scientific knowledge of the firm. Hence, knowledge-intensive entrepreneurial activity is more than knowledge-based; in fact it requires the development of existing knowledge bases through the creation of new knowledge or a new combination of existing knowledge not yet applied within the sectoral reference system of innovation.

Knowledge-intensive processes can become necessary in the light of newly emerging problems due to global changes, such as the intensified competition on world-markets that cannot be solved with the existing problem-solving knowledge. They can, however, also be triggered by problems or applications that can be solved better by means of knowledge-intensive activities and that promise a competitive edge. An essential prerequisite for knowledge-intensive entrepreneurship is the capability of a company or even of an individual entrepreneur to question existing knowledge and to identify and acquire (new) relevant knowledge from other knowledge bases.

So far, the debate on KIE has mainly focused on new technology-based firms or academic start-ups in high-tech sectors. To date, little attention has been paid to sectors that do not conduct R&D and that can therefore be characterized as non-research intensive or "low-tech". In particular, practical and experience-based knowledge has been overlooked in this discourse. In this contribution, we will therefore pose the question what KIE can mean in the context of low-tech sectors and which specific characteristics it has.

To answer this basic question, this paper proceeds as follows: the main features and relevant aspects of the low-tech sector will be presented in section 2. In section 3, we will draft an analytical model as a guideline for the interpretation of empirical findings concerning KIE in low-tech sectors. Section 4 comprises the preliminary and currently available empirical findings concerning this issue and in section 5, first conclusions will be outlined. Methodically the paper has an exploratory character. It is based on case study findings from a recently finished European project and preliminary case study findings from a currently ongoing European project (see section 4.1).

2. Low-tech sectors

2.1 Basic aspects

The term "low- technology" denotes those industrial sectors that, on average, have no or low research and development expenditures. The basis of this categorisation is the R&D intensity indicator, which measures the ratio of the R&D expenditure to the turnover of a company or to the output value of a sector. By means of this indicator, sectors with a R&D intensity of more than 5 % are characterized as "high-tech", or "high technology" and those with a R&D intensity between 3% and 5% as "medium-high-tech", or "complex technologies".¹ Sectors with a R&D intensity between 3% and 0.9% are classified as "medium-low-tech" and those with a R&D intensity below 0.9 % as "low-tech". Regarding the industrial sector, primarily "mature" industries such as the manufacture of household

¹ This indicator covers in-house R&D expenditures for R&D staff, further R&D costs and investments as well as out-house expenditures for, e.g., R&D tasks assigned to other companies and organisations (OECD, 2002: 108).

appliances, the food industry, the paper, publishing and print industry, the wood and furniture industry and the manufacture of metal products - such as the foundry industry - as well as the manufacture of plastic products are regarded as low-medium-tech. In contrast, pharmaceuticals, the electronic industry, medical engineering and vehicle construction, the aerospace construction industry as well as large parts of mechanical engineering as well as of the electrical industry are categorised as high-tech and medium-high-tech (cf. OECD, 2005).

Low-tech sectors continue to be of surprising importance and to persist even in the advanced, knowledge-based societies of the Western countries. In relation to the manufacturing industry as a whole, the low-tech (including low-tech and low- and medium-tech) sector in the EU 27 had an employment share of approx. 57% in 2006. The respective share of the high-tech sectors accounted for only about 10%.²

2.2 Constraints and opportunities for KIE in low-tech

Following from these basic features of LT industries, it must be assumed that the constraints on KIE activities in these sectors are significant. The main features of KIE are considered to be the focus on unexploited opportunities, the dealing with uncertainties, the creation of new knowledge and the overcoming of established routines on the company and at the sectoral level (cf. Cohendet and Llerena, 2010). However, low-tech sectors and firms seem to offer only very limited opportunities for these activities. The reason for this is that innovations in LT sectors are known to be path-dependent and based on a relatively slow accumulation of capabilities around previously known technological specialisation. This path-dependency is continuously stabilized by incremental innovation activities, by increasing returns as the result of the continuously optimized processes of the existing technologies and the therefore basically emerging momentum of these developmental paths.³ As available research findings show, this holds true in particular for entrepreneurial activities in the context of established companies (Parhankangas and Arenius, 2003). Unlike high-tech sectors with their prevailing technological contingency, the technologies of the LT sectors are well known and established and the processes and products are not only highly standardised and routinized but also at an advanced stage. The same holds for the knowledge base, which includes mostly codified, transferable and well-known elements such as design methods, engineering routines or the know-how about markets and customer preferences. Therefore, technological norms, methods and leitmotifs as well as occupations and skills are well developed and have existed for many generations.

² Own approximation based on: OECD Science, Technology and Industry Scoreboard 2008, Annex A: 183, Eurostat Database 2008.

³ Cf. the concept of path dependency in social sciences and innovation theory (cf. Garud and Karnoe, 2003; Beyer 2005). In this perspective incremental innovations can be regarded as "small events" not changing but only stabilising existing paths.

Furthermore, sales markets conditions do not at all trigger KIE-based activities. The reason is that these conditions are mainly characterised by a strong competition based on prices and cost forcing companies to optimize continuously their processes and technologies rather to pursue risky innovation activities. In other words, the economic success of LT companies is normally linked to professionalised managers whose job it is to optimize, to rationalise and to streamline the processes of their companies along the given trajectories in order to meet the needs of the intensive price competition on the internationalised sales markets. Thus, entrepreneurial activities in the aforementioned sense have only limited chances due to the fixed LT technological trajectories and the costly uncertainties they may produce.⁴ To sum up, it cannot be denied that unlike the field of high-technologies, the socio-technical field of LT industries offers only a few opportunities to step up economic success. Aggregated economic data on growth rates and the development of employment in low-tech industries convincingly prove this (cf. EFI, 2010). In this perspective one has to claim that “valuable opportunities” (cf. Radosevic, 2010) for KIE are strongly limited.

However, contradictory tendencies that go along with opportunities for KIE in low-tech should not be overlooked. Theoretically, it can be argued that paradoxically the situation of a fixed path-dependency can stimulate new ideas and attempts to overcome this and therefore a new path can be created. The majority of actors involved may look at new ideas and inventions as a cul-de-sac whereas for a minority of economic actors this situation offers opportunities with a high potential for economic success (Deutschmann, 2008). It may be also argued that competitive pressure will force managers to change their role by adopting an increasingly reflective approach towards established practices and by looking for breakthrough innovations (Beckert, 1991). This reflective approach may be triggered by a situation when formerly increasing returns may cease to increase or may even turn into decreasing returns (Deeg, 2005: 173). This situation may be caused by a continuously intensifying market competition and a growing pressure of low-cost competitors. Generally, it can be assumed that the intensive competitive pressure in LT industries forces actors not only to adopt managerial strategies of cost cutting and optimizing existing routines but may also compel them to adopt a reflective stance towards the established practices in order to overcome this situation. Especially because of the high persistence and stability of LT industries, entrepreneurial activities and a successful deviation from established practices and technological paths promises competitive advantages and a high profitability.⁵

⁴ Whereas a manager orients his decisions on routines, adaptation and imitation, entrepreneurs are characterized by a reflective stance towards taken-for-granted scripts and existing institutional regulations – following Schumpeter’s distinction between the manager and the entrepreneur (Schumpeter, 1997: 110).

⁵ This argument refers to the debate in organizational sociology on “institutional entrepreneurship” which reintroduces agency, interests and power into an institutional analysis of organizational change (cf. Beckert, 1999; Garud and Karnoe, 2003; Garud et al., 2007).

Empirically, recent research findings show that opportunities for KIE in LT industries do in fact exist:

- First, long term empirical studies show that knowledge diversification tends to prevail over a mere deepening of the existing technological paths (Mendonça, 2009) and also draw attention to the all in all surprising stability of LT industries in many OECD countries (Kaloudis, 2005). From this it might be concluded, that the usual findings tend to underestimate the true extent and depth of entrepreneurial change in mature businesses (Mendonça, 2009: 479).
- Second, recent findings of case study research emphasise the specific innovation ability of the low-tech sector and its companies (Tunzelmann and Acha, 2005; Hirsch-Kreinsen, 2008). According to these findings, low-tech companies very often do not only pursue incremental innovation strategies but also try to overcome the existing paths of knowledge and technology in the context of more far-reaching innovation activities such as architectural or modular innovation strategies. In part, such companies explicitly pursue strategies aiming at a leading position in niche markets beyond the main fields of standardised mature products or – connected therewith - they try to create new market segments.
- Third, research findings show the impressive success of so-called “gazelles”, i.e. fast-growing companies, often from LT sectors, which induce sectoral growth and create new jobs and new markets. Such companies can be found both in Western countries and in particular in the countries of Middle and Eastern Europe (cf. Yudanov, 2007; 2009).

These findings can be interpreted as first indicators for existing KIE processes even in LT sectors. However, if this is so, the prerequisites, the mechanisms, generally the distinctive features of KIE in low-tech are still rather unclear. These aspects will be discussed in more detail in the following sections.

3. KIE in low-tech

If there is scope for KIE processes in LT sectors, it can be assumed that these are characterised by specific features that differ from those already discussed in the KIE debate which has mainly focused on high-tech sectors. To be able to identify these features one has to differentiate and specify the aforementioned generalized aspects of KIE (see section 1). Firstly, one has strongly to emphasise that KIE in LT does not include only newly founded companies but it takes place also in the context of an existing organization or within an established company. This perspective may be of particular importance in LT sectors due to the competitive pressure may force existing firms and their managers to change their competitive situation by adopting an increasingly reflective approach towards

established practices and by looking for breakthrough innovations. Secondly, it can be assumed that the strong structural path-dependency in LT industries can only be overcome by activities of individual agents or firms referring to technological, institutional and market opportunities and in particular to knowledge which are new compared to the structures and knowledge of the already existing sectoral system.

That means that available trans-sectoral knowledge about technological, market and institutional conditions can be regarded as the *necessary condition* for KIE in LT sectors. Firms and individual entrepreneurs cannot be the drivers of KIE processes if they only rely on their specific sectoral knowledge, instead they have to build up relationships with actors, resources and opportunities from outside the sector, e.g. with the sector of a new customer. Hence, a sectoral system should be not understood as a closed system, as it is influenced by the conditions of various other systems it is linked to; e.g. it is embedded in regional, national and supra-national innovation systems and there are always relationships to other sectoral systems, especially along intersectoral product supply chains. Companies can have various linkages with actors outside their sector and the significance of these external ties has been increasingly recognised as crucial in accelerating technological change.⁶ In this perspective, Robertson and Smith (2008) emphasised the particular relevance of the “distributed knowledge base” for the innovativeness of companies from LT sectors.

Complementarily the activities at the level of individual firms or entrepreneurs have to be regarded as the *sufficient condition* for KIE in LT sectors because they are the causative factor which can bring about a transformation and renewal of a whole system. Sociologically spoken, institutional and technological arrangements of a given sectoral system can only be changed by the activities of actors who leverage resources to create new or to transform existing institutional arrangements. The central prerequisite for these activities is that a firm or an entrepreneur is able to adopt a reflective stance towards institutionalized practices and can envision alternative modes of getting things done (Beckert, 1999).⁷ Referring to conceptual considerations on the innovativeness of low-tech companies (cf. Bender and Laestadius, 2005), it needs to be stressed that such reflective competences of firms depend heavily on specific *capabilities*, a term provided by the well-known “resource based approaches” of innovation research. The core finding of this approach is that innovativeness, and therefore also KIE processes, may be analysed in terms of capabilities for orchestrating and mobilising knowledge and other resources at the disposal of actors and firms (cf. Teece and Pisano, 1994).

⁶ Cf. similar arguments in the debate on “Open Regional Innovation Systems” (Belussi et al., 2010)

⁷ See again the debate in organizational sociology on the relevance of “institutional entrepreneurship” for institutional change. Generally, this topic marks an open theoretical issue in the broad field of institutionally based approaches of innovation analysis (cf. Werle, 2005)

Linking these aspects with the aforementioned general features of KIE, one can sketch out an analytical model for the empirical investigation of KIE LT. Due to this concept the term knowledge is of utmost importance. It is relevant on the different levels of structure and agency and therefore knowledge has several meanings and functions summarized in Franco Malerbas definition of an entrepreneur as "...knowledge operators, dedicated to the utilization of existing knowledge, the integration and coordination of different knowledge assets, the creation of new knowledge, and engaged in the development of new products and technologies." (cf. Malerba, 2010: 6) That means the term knowledge refers firstly to available knowledge about technological, market and institutional opportunities which have to be considered as central pre-conditions of KIE on the level of an innovation system. This stock of knowledge has to be identified, to be evaluated and to adopt by individual firms and entrepreneurs in order to create new knowledge and innovation on the firm level; in other words, it has the character of input for KIE processes. Secondly, this term refers to knowledge as the prerequisite of entrepreneurial activities on the firm level and thirdly it includes also the outcome of these activities in terms of new products, technologies etc. Generally, the term knowledge should be used in the context of this different meanings as clearly as possible. Following this the main dimensions of this model are:

- First, the *trans-sectoral level of knowledge* about new technological, institutional and market conditions transcending the sectoral-specific knowledge base; this level can be also termed as *global knowledge* as it refers to conditions, practices, and information which are generally available.
- Second, the *sectoral level of knowledge* which represents the sectoral specifics and the established technological paths and which offers only limited or even no opportunities for KIE.
- Third, the *level of the individual firm and/or individual actor resp. entrepreneur*, including the dimensions of the existing knowledge and capabilities with various dimensions; this level can be also termed as the *local level of KIE* as it embraces firm or actor-specific features of KIE.⁸
- Fourth, *innovation* as the outcome of KIE;
- Fifth, the *impact* of KIE innovation on the local and the sectoral level; as outlined this dimension refers to the "Schumpeterian" character of innovation, i.e. it is not only new to the firm but also new to the whole sector.

According to the system perspective, additional *moderating factors* have to be taken into consideration. These are factors influencing and modifying the KIE process, e.g. innovation policy, aspects of

⁸ Cf. conceptual insights from science and technology studies referring to the distinction between *local and global levels of social order* (Rip, 1997; Disco and van der Meulen, 1998).

regional proximity or corporate finance. In a first approximation this model can be figured as follows:

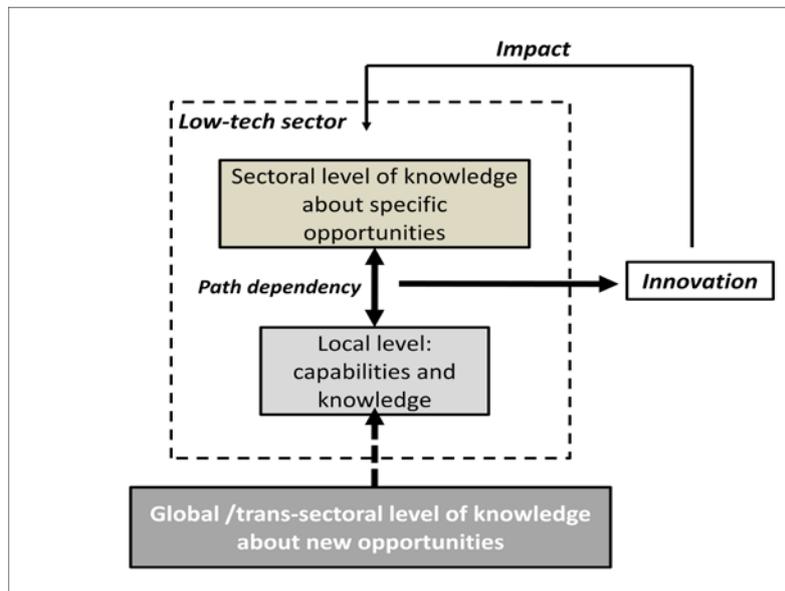


Fig.: Model of KIE in low-tech

4. Empirical findings

4.1 Methodological remarks

The intention of the following section is to analyse processes of KIE in low-tech in an *exploratory* manner. Therefore, the empirical findings presented in following sections are not of a representative character but rather function as instruments of probing into the factors and mechanisms relevant for a KIE process which were conceptually developed in the context of the aforementioned model. For this reason, the following interpretation is based firstly on a reinterpretation of selected findings from studies on low-tech innovation, in particular relevant case study findings from a recently finished European funded project on innovativeness of low-tech companies. Secondly, the interpretation is based on the preliminary results of fourteen qualitative, explorative case studies in selected low-tech companies conducted in an ongoing European funded research project. Case studies are currently being conducted in the sectors food, beverages & tobacco (NACE 15/16), textiles, apparel & leather (NACE 17/18/19) and metalworking (NACE 27/28). The selection criteria of the case study companies are: New companies which should have been founded between 2000 and 2006. Existing companies should have implemented the innovation between 2000 and 2006. The company should evidently be a first mover or be assigned to the most innovative companies in the market or product

field. Case study companies are SMEs, i.e. have less than 250 employees. The innovation implemented by the investigated company can be either a new product or a new, not previously applied, process (technology). The knowledge embodied in the innovation is not necessarily based on high-tech and R&D activities (but is not excluded). The case study companies are located in different southern European (Greece and Portugal) and western European countries (Denmark and Germany). Because of the exploratory character of this study the different national settings of the companies will not be considered systematically.

4.2 Dimensions and mechanisms of KIE-LT

4.2.1 *Trans-sectoral knowledge*

As emphasized the trans-sectoral knowledge on the global level refers to knowledge elements that are new compared to the sector-specific knowledge stock. According to the available empirical findings, primarily the knowledge about new technological opportunities can fall under this category. In most cases investigated this new knowledge has been scientifically generated and is based on the results of applied research in sciences or it has been generated by means of inventions in the realm of mechanical or electrical engineering. Furthermore, knowledge about new market opportunities is important. Empirical examples are the identification of undeveloped market segments and market niches which are actually created by the development of new products targeted to these niches.

An example from the literature is a very successful producer of "middle class" footwear in Russia at a time when the Russian footwear industry was collapsing under the pressure of foreign competition (Yudanov, 2007). Another example is a producer of swivel-chairs who created new market segments by offering an extensive service support for his fashion-oriented and newly designed products. A prerequisite for the new design of these chairs is the knowledge about general fashion trends in the design of household goods that is new to the sectoral knowledge base. The starting point for this market-oriented strategy is the knowledge about the limitations of and the strong competition on the traditional market for office furniture which can only be overcome by identifying so far overlooked customer preferences.

In other cases the competences of sectoral-external suppliers are of particular- sometimes "strategic" - importance. By virtue of their specific knowledge of materials, production possibilities etc., these suppliers give important impulses for the further development of low-tech products and can compensate the knowledge deficits of the respective enterprises. Typical examples are suppliers of specified materials such as special steel and print colours or of machine components as well as of devices that are indispensable for the innovation of products. In the case of metal-working companies, for

instance, this often concerns suppliers from high-tech sectors whose services are an indispensable condition for innovation strategies.

4.2.2 Sector-specific knowledge

In the case of LT industries, the sector-specific knowledge includes mainly application-oriented knowledge concerning e.g. technological standards, organisational routines, management concepts and marketing strategies and given market conditions as well as related institutional factors such as occupational and skill structures. Its application-oriented character implies that this knowledge can to a great extent be characterised as practical or even tacit but it also encompasses the utilisation of science-based knowledge. Typically, this sectoral knowledge is one of the causes for the occurrence of incremental innovation activities and path dependency in LT sectors (see section 2.3). Therefore, in many cases the sectoral knowledge base has to be regarded as an important starting point for KIE activities, but this knowledge as part of the established structures that need to be overcome. As the empirical findings show, the sector-specific stock of knowledge is relevant for KIE-LT only in an indirect sense. It offers no or only limited opportunities, nonetheless the acquaintance with it is crucial for attempts to develop specific acquisition strategies for relevant cross-sectoral knowledge. The findings of a case study of a start-up in textiles and clothing convincingly show this: The knowledge about the ongoing intensification of the international competition in the textile industry, particularly on the part of Asian competitors, has led to the search for new markets and differentiation strategies for product value enhancement in this industrial sector. In this context, the demand for functional textiles opens up new market opportunities. Another example is the aforementioned producer of stylish swivel-chairs. The starting point for the innovation strategy of this firm was the knowledge and firm conviction of the firm's management that the sectoral technological paths and market structures no longer offer any opportunities for economic success.

4.2.3 Local level

a) Local knowledge

The *knowledge at the local level of an individual firm* – be it an already established company or a newly-founded company - includes codified elements (instruction handbooks, formal organisational rules, technical process protocols etc.) as well as uncodified elements (e.g. informal practices, traditions, habits etc.); it is characterised by some degree of tacitness. Generally, the prevailing form is practical knowledge due to the absence of R&D departments and scientifically based activities. As the empirical findings show, this type of knowledge, i.e. the detailed and broad know-how of the firm's situation, of its strengths and weaknesses, is *in most cases* the crucial precondition for explor-

ing new opportunities to overcome the limitations of the existing paths. A convincing example in this respect is the occupational history of the owner of a cookware manufacturer who started at the floor with a huge amount of practical activities. Another example are the case study findings on a metal-working company, an automotive supplier, described in the literature (cf. Hirsch-Kreinsen, 2008). This company introduced process technologies which can be regarded as totally new for the whole sector. An indispensable precondition for this innovation was the firm-specific practical knowledge in various forms gained in the respective operative process, thus, e.g., about the shortcomings of and problems with the applied production technologies and about their effective technical, organisational and, of course, economic application and utilisation potentials. The introduction of the new technology took place in the context of the ongoing operative processes. It was initiated and pressed ahead with by the staff responsible for the ongoing functions, such as engineers, technicians, master craftsmen and qualified workers.

Another example is a start-up firm that manufactures different types of cellulosic fibres: The local knowledge base was developed step-by-step and comprised manufacturing (procedural) knowledge and marketing knowledge. In addition, it also included knowledge about customer interests and needs. A further element of the local knowledge base is know-how about the technical processes of the customer. All in all, the formation of the local knowledge base is directly linked to the development of the new product and the use of the new trans-sectoral knowledge. At the same time, it strongly refers to the existing sectoral structures in terms of market conditions and customer demands. However, local practical knowledge does not seem to be important in all cases. An example for this is a start-up in food and beverages which is based only on trans-sectoral scientifically created knowledge.

b) Capabilities

The use, the combination and the creation of new knowledge depend on the described stocks of knowledge and the respective opportunities. However, whether and how this process takes place depends in particular on the existing capabilities of a firm or an individual entrepreneur. Capabilities are characterised by attitudes, skills and experiences of decision-makers having developed through learning processes. The term capability should not be understood as a pattern of activities, but rather as a term with which to address specific conditions for specific activities: a particular configuration and constellation in the company that in particular enable the deployment of the company internal and external knowledge resources, which potentially constitute KIE for this organisation.⁹ Empirically, the capability to utilise knowledge is to a large extent dependent on the routines and structures

⁹ Cf. the longstanding discussion on the capability approach in innovation research (e.g. Teece and Pisano, 1994)

of the company organisation, for instance the mode of the division of labour, the prevailing communication and co-operation forms and the therewith connected qualification and personnel structures. Following the findings of low-tech research, two kinds of capabilities can be regarded as crucial (cf. Bender and Laestadius, 2005; Hirsch-Kreinsen, 2008):

(1) *Configurational capability* is the first essential element. It constitutes an enduring ability to synthesise novelty on the local level by creating new configurations of knowledge, artefacts and actors.¹⁰ It refers to the ability of the individual actors involved (skills, degree of management professionalism, learning-methods, instruments etc.) to tap distributed knowledge and know-how from diverse areas and to recombine it creatively with already existing local knowledge. Typically these actors are the leading managers or owners of an existing firm or the founders of a new one. It also points to the organisational dimension of the knowledge required to use and create processes at the local level. These organisational abilities - in particular existing routines or internal communication processes - facilitate the combination of elements of knowledge and technology but also the link-up of actors who possess relevant knowledge, technology and competence. For instance, management attempts to approach product and process innovations strategically by defining development projects with a certain priority and by setting up target agreements together with a few engineers and master craftsmen in their staff are an example of this capability. Fashion-oriented clothing manufacturers who pursue a new niche strategy by creating new market segments are another example: One can find relatively well-established procedures that generate product ideas within the context of the ongoing production process itself. These procedures have been well-rehearsed in the course of the years.

The case of a metal working company is also characterized by a high degree of configurational capabilities. Obviously, the company is able to monitor the external evolution of important technological aspects and to integrate this knowledge into its own knowledge base. These monitoring activities cover the developments in telecommunications, energy, aerospace, security and similar areas relevant for the company and its products. The capabilities of the founder of the company are exemplary in this respect: He had many years of field experience and developed the vision of building an organization that would be integrated across the products and services of his field with the primary goal of serving the customer in the best way (fast delivery, flexibility, total solutions).

(2) The second essential capability refers to the capability to establish and manage relations to external partners – termed as *transformative capabilities*. Due to the described relevance of the trans-sectoral knowledge base, this specific capability has to be regarded as crucial for utilizing the respective opportunities. It constitutes the enduring ability to transform existing general, global knowl-

¹⁰ The notion of configurational capabilities has a high resemblance to the term “combinative capability” introduced by Kogut and Zander (1992), which they explain as generating new applications only from existing knowledge.

edge into local level knowledge, i.e. plant, firm or task specific knowledge and competence. This is a core competence in LT industries: it refers to the transfer of the sector-specific knowledge on LT industrial techniques like welding etc. and the transfer of trans-sectoral knowledge, which is an important precondition for KIE processes. Mendonça (2009: 476) stresses this point as follows: low-tech firms "...demand some degree of endogenous capabilities in order to understand, procure and interact with the partner-suppliers to facilitate the production of renewed traditional goods." Therefore, the company ability to manage and effectively co-ordinate network relations across company borders with other companies within the value chain, research institutes, universities or specialised consultants, is a central precondition for successful KIE LT (e.g. by means of adequate channels of communication and interfaces, network management skills etc.). This capability has both a formal dimension referring to contracts and agreements on the aims, the schedule and the investments to be made and an informal side.

An empirical example is the case of a textile and clothing start-up. As it is characterised by limited scientific knowledge base it hinges on the collaboration with a research institute. This collaboration is assured due to the fact that one of the company's managers is simultaneously responsible for (the limited) R&D within the company as well as for the direction of the private research institute. He has a very important function as a boundary spanner because he has the latest technical know-how but also knows which people in the institute can evaluate the technical feasibility of ideas. For another thing, there is the formal license agreement that ensures the company's access to the latest scientific knowledge of the research institute that can act as a further formal source of innovation. Moreover, it can be assumed that there is a tight informal network between the research staff of the company and the research institute that ensures information exchange.

4.2.4 Innovation

Another main characteristic of KIE is innovation, which should not only be new to the firm but also new to the whole sector. However, innovation basically has to be regarded as the outcome of the KIE process. As already outlined, this process is based on the opportunities provided primarily by the stocks of sector-external knowledge. It is normally put into practice by capability-driven activities on the firm level. Innovations are the result and they have an impact on the technological and economic development in general. To specify typical innovations in LT sectors, one firstly has to exclude the type "incremental innovation" because it occurs routinely and is based on existing firm-specific or sectoral knowledge. This innovation type is typical for and widespread in LT sectors but it does not affect and overcome the established sectoral situation. Secondly, one has to exclude the type "radical innovation", as it seems highly unlikely in fields of traditional technologies. The reason for this is that even far-reaching innovation activities in LT sectors are linked to the existing knowledge and

technological paths, which will normally not be overcome. Thus, oriented on the well-known taxonomy of Henderson and Clark (1990), one can conclude that two types of innovation can be regarded as typical for KIE-LT: *architectural and modular innovations*.

(1) The term architectural innovation denotes the recombination of existing components in order to obtain a new product design or a new technical and organisational structure of the production process. It does not only make use of given technological core concepts and knowledge assets and develops these further, but also to some extent integrates new knowledge elements. Thus the framework of the chalked out development paths is not completely overcome but is extended to some degree. This type of innovation can be illustrated by a company innovation strategy which is characterised by innovation measures that are directed at securing and improving the sales market situation of the enterprise. This, for instance, holds good for the fashion-oriented design of products, the functional and technical upgrading of products, a rapid response to changing customer wishes, taking advantage of market niches, skilful branding strategies and the expansion of product-related service activities. Company activities in the textile and clothing industries and from furniture and leather goods manufacturers are examples for this strategy. The product development is geared to anticipatable fashion cycles, whose existing product lines demand a more or less continuous variation. A further example is an office furniture manufacturer who, at very short notice, accepts the order of a big retailer with much market power for a large number of speedily to be supplied office furniture products of a new, not previously produced type and who correspondingly diversifies his products. In various other cases one can also ascertain a broadening of the spectrum of offers as companies supplement their process functions with service offers and logistics services tailored to certain customers.

(2) The type of modular innovation requires new knowledge for one or more components of an existing technological system, but the architectural knowledge of the whole system remains unchanged. However, very often this does not only result in a marginal improvement of an already existing system of technology but in a structural change in the whole system. On this basis the respective companies are able to overcome existing technological routines and paths on the sectoral as well as on the local firm level. The enterprises investigated which can be linked to this type of innovation belong e.g. to industrial subsectors with products that are mostly manufactured on a relatively high level of automation and with integrated process technologies. An example for this strategy is the furniture industry, which is extensively automated on the basis of a significantly reduced variety of parts and of simplified processes. A second example is the continuous development of processes in wood-working which has, according to the experts, in the meantime achieved an extremely high level of process performance and process precision that is hardly comparable to other industrial sectors.

Similar trends can also be discerned in sheet forming companies and firms manufacturing plastic parts, mechanic components or aluminium parts. A third example worth noting is paper manufacture and the intricate processes in the food processing industry, in which technologically elaborate processes are continually being optimised and developed further.

However, sometimes low-tech companies pursue innovation activities that mixes both innovation types. An example for this is a manufacturer of cookware, who first introduced a new material, realising a so-called multilayer technology for cookware – a typical modular innovation. Secondly, he focused on a sophisticated new and flexible design aiming at different market segments – a typical architectural innovation.

4.2.5 Moderating factors

According to the system perspective relevant for the analysis of KIE, moderating factors have to be taken into account. These are factors modifying the relationship between the KIE process and the innovation as its output. Following the system analysis perspective in general (cf. Edquist, 2005) and conceptual considerations about innovation in LT sectors (cf. Tunzelmann and Acha, 2005; Bender, 2005; Hirsch-Kreinsen, 2008), in particular the following aspects need to be considered:

a) *Institutional conditions* that are only indirectly linked to technology development and innovations, i.e. the degree of the institutional “embeddedness” of the KIE process and the supporting and/or restricting role of the global institutional environment for the process of KIE-LT. According to the innovation systems approach, this especially pertains to socio-institutional conditions such as the education system and.

a) Innovation policy

The political system with innovation supporting measures and to more indirectly innovation-oriented measures such as taxation or loan provision do hardly affect KIE processes in low-tech. This holds in particular for innovation policy measures which, on the one side, are usually not targeted at the specific needs of LT firms. This situation has been often referred to as “lacking awareness” of innovation and economic policy actors towards the needs of non-research-intensive industries. At best, such measures indirectly promote the innovation ability of LT companies, insofar as they are generally directed at the improvement of industrial production or the support of newly founded companies. On the other side, from the point of view of the individual companies, innovation policy measures are often regarded as “extremely complicated” and “inflexible” and too bureaucratic.

Only very seldom policy measures are of major importance for KIE processes. An outstanding example for this is a textiles and clothing start-up which participated in various industrial promotional

programs of the German federal government. With the help of the programs, a pilot plant at the testing company was financed and material testing and experimenting with materials in cooperation with other companies were promoted. However, these programs did not specifically target innovative activities in traditional sectors but generally and unspecifically supported the foundation of new companies in the underdeveloped East German area where the case study company is located. More generally, the findings show that it is only by chance that LT companies can participate in public support programmes at the national as well the European level because promotion measures are often laid out in a sector-unspecific way or are aimed at the support of research and high technologies and not at the specific concerns of low-tech enterprises.

b) Regional proximity

Regional proximity is, to a greater or lesser extent another moderating factor influencing KIE processes indirectly. It is regarded as important for mutual information and face-to-face communication processes in which especially tacit knowledge is transferred. The prerequisite for such an exchange is a stable regional milieu which promotes a common understanding of technological development but which is also open enough to avoid lock-in effects. The empirical findings show that sometimes, but not always, regional proximity is an essential precondition for successful KIE processes. This means that the collaboration with suppliers, competitors or other supporting organisations such as consultants or research institutes may compensate for the lack of resources of low-tech SMEs.

An example for this is the aforementioned cookware producer and its network with local "rivals". This network is regarded as an important factor for the firm's success at home and abroad. The same can be said about a start-up in food and beverages. Furthermore, some findings stemming from already finished studies can be cited here (cf. Garibaldi and Jacobson, 2005): According to these, particularly companies with a market-oriented strategy benefit from spatial proximity, which must be regarded as an important factor regarding supplier relations, as logistic problems can thereby be avoided and the rapid availability of parts and components is thus guaranteed. In many cases, spatial proximity also plays an important role for customer relations as thus, most notably, the ability to deliver overnight is guaranteed. Moreover, one should not overlook aspects such as regionally established occupational training and further education institutions, which are credited with an important supporting function particularly by process specialists with their special qualification needs. As the training imparted by these institutions is often geared to the needs of LT companies with highly automated production technology, a relatively trouble-free and fast recruitment of correspondingly qualified staff is often guaranteed. Finally, regionally established and accordingly specialised scientific organisations, technology liaison offices, political institutions, associations, chambers of commerce and industry or also regionally focused support programmes also play a certain role for the

success of KIE processes. For such actors and activities oftentimes provide knowledge that can initiate company learning processes which can lead to concrete KIE measures.

c) Finance

Corporate financing has to be regarded as an additional but fundamental precondition for innovation activities and entrepreneurship inasmuch as it is here that decisions are made on the conditions for and volume of capital allocation to enterprises. More specifically, the different financial market terms entail different forms of corporate financing, specific systems of corporate governance as well as divergent latitudes for entrepreneurial strategies. It can be assumed that there are only limited possibilities of obtaining financing for KIE activities because of the lacking of intangible assets and the difficulty to calculate the risks and uncertainties of the innovations (cf. Malerba, 2010). This situation holds true in particular for KIE in low-tech because innovations in traditional sectors are of minor interests for investors. Usually they are considered as to be of limited novelty and therefore they offer only limited chances for profits (Hirsch-Kreinsen, 2011). Empirically there is only some information concerning the financing modes of KIE activities in LT. Based on the preliminary findings, one can say that family and friends networks or public funds are relevant sources of finance in the starting phase for start-ups. In contrast KIE activities in established companies are often financed by internal funds like an available free cash-flow in order to avoid unwanted influences of external financiers.

4.2.5 Impact

Finally one also has to take into consideration the impact of successful KIE processes and associated innovations. They affect the company level, the sectoral and the trans-sectoral level. Of course, the company knowledge base is expanded in the course of a KIE process. But the sectoral and trans-sectoral knowledge base too undergoes a change process as the impact of successful KIE activities creates new technological or market opportunities which are sooner or later available to other companies imitating the KIE process. As a result, not only new sectoral structures but also new potentials for growth and employment and therefore new opportunities for KIE activities may be created. As the findings show, impact mostly means the creation and the establishment of new market segments by means of new products and service activities and furthermore the use and diffusion of new process technologies, management and organisational concepts.

For instance, there is a significant impact of the activities of the aforementioned textiles and clothing start-up at all levels: at the local firm level there have been several follow-up innovations that apply the platform technology of innovative fibres. Since its foundation, the company has launched a new fibre and three consumer product innovations. Currently negotiations are being conducted with a huge company group concerning the mass production of the second consumer product innovation,

an antibacterial washing-ball. According to one of the interviewed managers, this means that most of the prospective turnover of the company will be due to this licensing. The sectoral level has been affected in several ways: First, the market niche of functional cellulose fibres, in which the firm is operating, did not exist before for the product field of cellulose fibres. Second, the new fibres are adding value to the textile products of the customers in terms of new or improved functions such as material effectiveness, low material weight and environmental compatibility. Therewith, the new fibres contribute to product innovations and new fields of application for clothing and textile manufacturers. Additionally, these value added products help the exclusive manufacturers to realise high prices further on. Third, this knowledge base has been affected because the innovation offers further opportunities for new products and possibilities of application. With the new technology especially thin PCM textiles can be produced, e.g. shirts, whose production was not possible on the basis of the earlier sectoral knowledge base.

The impact of the KIE activities of the aforementioned producer of swivel-chairs can be characterized in a similar way. At the local level the innovativeness of the firm has been improved dramatically because new design principles were implemented. Contrary to the rest of the sector, this company now perceives an office-chair as a "whole system" (to quote one of the managers) whereas the competitors only look at the individual components of a chair. This new design perspective offers new opportunities for the development of office-chairs (see the section above on innovation). Consequently, the impact at the global level is also significant. The company was able to create new market segments at home and abroad with newly designed chairs. And the new design principles have gradually been imitated by European competitors, who have consequently gained a competitive edge on the world market.

5. Conclusion

Summing up, KIE-LT can be characterised in a preliminary manner as follows:

1. There is a distinctive technological and institutional path-dependency in LT sectors. The existing sectoral system of LT industries imposes strong constraints on KIE processes. KIE opportunities within the sectoral system are very seldom and hard to identify. Thus, a prerequisite for KIE-LT is that the barriers of the established developmental paths are overcome. Nonetheless, KIE-LT is always at least indirectly linked to the existing system structures. By contrast, KIE in high-tech sectors very often takes place in a situation that can be characterised as open and contingent due the relevant institutional and technological factors.

2. There seem to be two main preconditions for KIE-LT: Firstly, trans-sectoral factors provide oppor-

tunities for KIE. These include new knowledge and technologies that stand out from the resources of the existing sectoral system, in particular scientifically generated knowledge but also new combinations of practical knowledge. Furthermore, the knowledge about new markets (at home or abroad) is another important prerequisite for KIE-LT. However, these factors constitute opportunities as a necessary condition for KIE. Secondly, an essential prerequisite of KIE is the ability of the companies in question to identify these opportunities and to integrate and to use the new knowledge. A bundle of firm-specific capabilities is a crucial precondition for this. The basis of these capabilities is the knowledge stock of the firm, the skills of the staff and the organisational routines. Among these capabilities, transformative capabilities are of utmost importance because they constitute the sine qua non for the access to the whole stock of trans-sectoral knowledge and the respective actors.

3. Furthermore, KIE-LT may be activated within the aforementioned situation of stable path-dependency, which, for a minority of economic actors, offers opportunities for innovative activities with a high potential for economic success. In addition, the competitive pressure may force actors in the LT-sector to change their role and to adopt an increasingly reflective position towards established practices and to seek to break new ground with regard to innovations.

4. Architectural or modular innovations are the typical outcome of KIE-LT. The incremental innovation activities that prevail in these traditional sectors do not overcome established paths and routines and radical innovation activities seem to be very seldom. Especially architectural innovation activities seem to be very important for successful KIE activities because this innovation type does not only allow for flexible customer-oriented strategies but also for the opening up of new market segments as well as the stimulation of new customer demands.

5. As the empirical findings show, the impact of KIE-LT on the existing sectoral structures may be significant. Both the firm-specific and the sectoral knowledge bases and the structural and institutional factors behind the knowledge stocks are often changed. Consequently, successful KIE activities lead to the sustainable improvement of the competitive position of European traditional sectors and firms.

6. This usually occurs without major and targeted support of innovation policy at the national and European level. At best, LT firms can apply for state funded innovation projects which have a general character and are often targeted towards high-tech innovation activities. However, this situation could be significantly improved. Even the preliminary available findings point to possibilities for policy measures which would foster KIE activities in low-tech. These are e.g.:

- an improved access to trans-sectoral external knowledge especially for LT SMEs with their limited resources;

- the improvement of transfer processes of the available trans-sectoral knowledge to the sectoral knowledge stock and to the local level of individual firms or individual entrepreneurs;
- the enhancement of company capabilities to integrate and utilize new knowledge, e.g. by improving management competences, especially the company capability to cooperate and network in a trans-sectoral direction;
- the framework conditions, i.e. the moderating factors should be the object of policy measures, in particular with respect to innovation policy, regional proximity and networking.

These aspects need to be specified in the further course of research activities. To achieve this, a further differentiation between KIE-LT and KIE in high-tech sectors will be of particular importance. These differences may be a matter of degree only. One can probably speak of a spectrum with two extremes: on the one side KIE-LT, on the other side KIE in high-tech, with a smooth transition in between the two ends. However, this comparative perspective has not yet been systematically applied and will be a major issue of the future research.

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