Abstract

In the context of the debate on the emergence of knowledge-based societies knowledge-intensive entrepreneurship (KIE) is regarded as a central transformative mechanism that pushes this development. Consistently, the discussion about KIE has mainly focused on new technology-based firms or academic start-ups in high-tech sectors. Little attention has been paid so far to sectors that can be characterized as "low-tech". In this paper, the question is posed what KIE can mean in low- and medium-technology industries (LMT). On the one hand, it can be assumed that entrepreneurial activities have only limited chances in LMT industries due to their mature character. On the other hand, opportunities for KIE activities in these sectors can be identified. Based on the results of 27 case studies of industrial LMT companies four typical patterns of KIE activities will be outlined. In the paper the final results of a recently finished European research project will be summarized aiming at a first, but also deeper understanding of a so far disregarded issue.
Typical Patterns of Knowledge-Intensive Entrepreneurship in Low-Tech Industries

1. Introduction

In the context of the debate on the emergence of knowledge-based societies knowledge-intensive entrepreneurship (KIE) is regarded as a central transformative mechanism that pushes this development. Consistently, the debate on KIE has mainly focused on firms or start-ups in new technology-based high-tech industries (Cohendet and Llerena, 2010; Malerba, 2010; Audretsch et al., 2011). Therefore in this discourse no attention has been paid to firms that belong to so-called low- and medium-technology industries (LMT). As is well known, the term “low-technology” denotes those industrial branches that have R&D intensity below 3%. Regarding the industrial branches, primarily “mature” industries such as the manufacture of household appliances, textiles and footwear, the food industry, the paper, publishing and print industry, the wood and furniture industry and the manufacture of metal products as well as the manufacture of plastic products are regarded as LMT industries (OECD, 2005). Due to their mature character it seems very plausible that so far the ongoing debate on entrepreneurship have not focused at all on these industries. In other words, KIE in LMT industries can be regarded as a contradiction in itself.

Nonetheless, in this paper the question will be examined whether KIE activities can be identified in LMT industries, and which specific characteristics it has. In the paper the final results of a recently finished European research project will be summarized. This paper proceeds as follows: In section 2 we will discuss constraints and opportunities for KIE in LMT sectors. In section 3 we will draft an analytical framework as a guideline for the interpretation of empirical findings. Section 4 describes the qualitative methodological empirical base of the investigation, namely the case studies conducted in the project. Section 5 comprises the empirical findings, namely four empirical types of KIE in the LMT sector. In section 6 the findings will be summarized and first policy-oriented conclusions will be outlined. Due to its qualitative methodological base, the paper aims at a first, but also deeper understanding of a disregarded issue and the development of hypotheses which should stimulate further research.

2. KIE in LMT industries: constraints and opportunities

The main features of KIE consider unexploited opportunities, dealing with uncertainties, the creation of new knowledge and overcoming of established routines at the company and at the sectoral level (Cohendet and Llerena, 2010). However, it must be assumed that these opportunities are rare in LMT sectors.
The findings of LMT research support this: On the one hand, findings emphasize the specific innovation ability of LMT industries (Arundel et al., 2008; Hirsch-Kreinsen, 2008; Huang et al., 2010). On the other hand, these findings show a dominance of incremental, mostly process innovations and disruptive innovation activities are in contrast very seldom. Generally, the dominant pattern of technological development in LMT industries runs along the given technological paths and is based on a relatively slow accumulation of capabilities around previously known technological specialization. In other words, the LMT innovativeness is characterized by a high path-dependency which 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. Unlike high-tech industries with their prevailing technological contingency, the technologies of the LT industries are well known and established and the processes and products are not only highly 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. Furthermore, normal sales market conditions force companies to continuously optimize their processes and technologies than to pursue risky innovation activities. They do not trigger KIE-based activities at all. Rather, the economic success of LMT companies is linked to professionalized managers whose job is to optimize, to rationalize 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 sales markets. Considering this situation, entrepreneurial activities have only limited chances due to the fixed LMT technological trajectories and the costly uncertainties they may produce.

However, contradictory tendencies that go along with opportunities for KIE in LMT should not be overlooked. Based on conceptual considerations of entrepreneurial research this situation can be traced back to two interlinked determining factors:

Firstly, the activities of individual agents or firms can go beyond the borders of an established sectoral system; it may be argued that a majority of actors involved may look at new ideas and inventions as a cul-de-sac whereas for a minority of economic actors a situation of stable path-dependency offers opportunities with a high potential for economic success (Garud and Karnøe, 2003; Garud et al., 2007). It may be argued that competitive pressure will force managers to change their role by adopting an in-
creasingly reflective approach towards established practices and by looking for breakthrough innovations (Beckert, 1999). This reflective approach may also be triggered by a situation when formerly increasing returns may cease to increase or may even turn into decreasing returns (Deeg, 2005). Generally, the intensive competitive pressure in LMT 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 LMT industries, entrepreneurial activities and a successful deviation from established practices and technological paths promise competitive advantages and a high profitability. As research on entrepreneurship shows (Shane, 2003; Grichnik, 2006) such activities are based on two distinct abilities: The ability to take up given opportunities for KIE activities based on existing information about these opportunities and the ability to look actively for possible opportunities for KIE based on a specific “alertness” of the entrepreneurial actor.  

Secondly, these arguments refer to the concept of entrepreneurial opportunities presented in the entrepreneurial literature (Shane, 2003). This highlights that entrepreneurial activities can only be understood as a nexus of entrepreneurial activities on the micro-level of individual companies and valuable opportunities on the macro-level of economic, institutional, and technological structures (for a summary see Radosevic, 2010). This argument can also linked with conceptual findings in LMT research which emphasised the particular relevance of a “distributed knowledge base” for the innovativeness of companies from LMT firms, i.e. the relevance of sector-external knowledge stocks, especially scientifically created knowledge in high-tech industries for LMT firms (Robertson and Smith, 2008).

3. An analytical framework

Based on these considerations an analytical framework for the empirical analysis of KIE processes in LMT industries will be sketched out. The purpose of this framework is to guide the analysis of the empirical results in order to hypothesize typical patterns of KIE processes in LMT industries. Its basic dimension refers to knowledge. It is a constitutive feature of KIE processes that they call for more than the already existing and established procedural and scientific knowledge of the firm and its specific industrial sector. This means that scientifically created knowledge may play a major role in KIE-processes (Malerba, 2010). However, due to the specific mature situation of LMT industries also knowledge of operative or practical character may be of larger importance (Hirsch-Kreinsen, 2008).

To analyze KIE process in LMT industries the aforementioned concept of the “distributed knowledge base” will be taken up. Following Robertson and Smith a distributed knowledge base is a set of knowledges and knowledge sources maintained across an economically and socially integrated set of agents

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4 The first aspect refers to Schumpeter’s notion of innovative opportunities (Schumpeter, 1997), the second aspect to Kirzner who emphasized the discovering of opportunities (Kirzner, 1997).
and institutions.⁵ Referring to this concept, firms do not depend on a single source of technological knowledge. Rather, they must blend knowledge that is distributed among various knowledge bases according to such factors as industrial source, geographical location, scientific or technical location, social location and chronology (Robertson and Smith, 2008: 100).

Following this concept and the conceptual considerations about the constraints and opportunities of KIE processes in LMT industries three levels of knowledge can be distinguished:

- Firstly, the level of firm-specific knowledge which has a localized character and is specific to very specialized product characteristics in firms which they understand well; on this level especially the capability to purchase new knowledge and the capability to combine existing and new knowledge to a new level of knowledge has to be regarded as an important determining factor for KIE activities (Bender and Laestadius, 2005).

- Secondly, sector or product-field-specific knowledge; at this level there are shared scientific and technological understandings concerning e.g. the functions, performance characteristics, use of materials of products. This level constitutes a body of knowledge and practice which shapes the performance of all firms in an industry.⁶ As aforementioned, it has to be assumed that this sectoral situation is characterized by a strong path dependency and competitive pressure.

- Thirdly, generally applicable knowledge which includes to a larger extend to generally available mostly scientific knowledge which is basically new for established industrial sectors. However, following entrepreneurial research (Shane, 2003, Radosevic, 2010) this level encompasses also market, technological and institutional opportunities beyond the specific and restrictive situation of the LMT firms and sectors. Therefore, this level of globally available knowledge may constitute an important determining factor for successful KIE processes in LMT sectors.

It can be argued that these three levels of knowledge, their characteristics and specific combination constitute the determining factors of KIE processes in LMT industries. However, additional intervening factors have to be taken into consideration. These factors cannot be regarded as core dimensions of KIE rather they may modify the KIE process. Referring to the literature on LMT innovativeness such factors are of minor significance e.g. innovation policy and aspects of regional proximity (Jacobson and Heanue, 2005).

⁵ As the authors emphasize, this concept is based on a longstanding discussion in innovation research (Robertson and Smith, 2008: fn 9)
⁶ See also the concept of Sectoral Innovation Systems which highlights knowledge as a main building block of a specific sectors (Malerba, 2005).
The interplay of these factors leads to the outcome of the KIE process which has to be defined in terms of technological innovation. Due to the KIE perspective of this analysis one has to exclude the type “incremental innovation” which may be regarded as typical for LMT industries. This innovation type is typical for and widespread in LMT branches but it does not affect and overcome the established industrial situation. Thus, oriented on the well-known taxonomy of Henderson and Clark (1990) and research findings on LMT innovation, one can conclude that “architectural” and “modular” innovations can be regarded as relevant for KIE-LMT. But due to the connotation of KIE, radical innovation cannot be completely excluded either.

Finally, one has to emphasize – unlike the general debate on KIE (Malerba, 2010) - that the focus on KIE in LMT has to include not only newly founded companies (start-ups and spin-offs) but also change processes in established companies, termed as corporate venture. The reason for this extended perspective is that in traditional manufacturing sectors with mature technologies newly founded companies based on new technological knowledge may be more unusual than in high-tech sectors with their technologically less established situation. Besides they would probably face high entrance barriers.

4. Methodology
4.1 Data base

The intention of this paper is to analyze processes of KIE in LMT industries in an exploratory manner. It is based on the findings of case study research and it aims at a first understanding of a not yet investigated issue and the development of hypotheses which should stimulate further research. In other words, based on the outlined analytical framework the empirical analysis aims at a preliminary identification of the opportunities and patterns of KIE processes in LMT industries. Methodologically, these opportunities and patterns are of hypothetical nature which should stimulate further research.

The exploratory analysis is based on the results of 27 qualitative case studies that were conducted in the context of a European research project in 2009 and 2010. The case studies were conducted in the LMT branches food, beverages & tobacco (NACE 15/16), textiles, apparel & leather (NACE 17/18/19) and metalworking (NACE 27/28). The case study companies were either established or newly founded companies; the KIE process of established companies is termed as “corporate entrepreneurship”; newly founded companies include foundations by already existing companies or individual entrepreneurs termed as “industrial start-ups” or foundations from academic institutions termed as “academic spin-offs” (see table 1 below).7

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7 As the entrepreneurship literature underlines these three entrepreneurial modes should be basically treated as different (Stam and Noteboom, 2011). However, due to the exploratory character of this study the differences of these modes haven been not taken into consideration. Possible differences should be the topic of future research.
The selection criteria for the case study companies were: New companies founded between 2000 and 2006 and implementation of innovations in established companies between 2000 and 2006. Furthermore: The company should evidently be a first mover or be reckoned among the most innovative companies in the market or product field. The case study companies should be 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 (i.e. generally more than only incremental innovation activities). The case study companies are located in Southern Europe (Greece) and Western Europe (Portugal, Denmark and Germany). Because of the exploratory character of this study the different national settings of the companies and sectoral differences will not be considered systematically.

Table 1: The AEGIS LT case studies

<table>
<thead>
<tr>
<th>KIE-Modus</th>
<th>Textile</th>
<th>Food</th>
<th>Metal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corporate entrepreneurship</td>
<td>CTGR1, CTGR2, CTGE2, CTGE3</td>
<td>CFDK2, CFGR2, CFGR3, CFGE1, CFGE3, CFP2</td>
<td>CMDK2, CMGE1, CMP2</td>
</tr>
<tr>
<td>Industrial start-up</td>
<td>CTDK2, CTP2</td>
<td>CFDK1, CFGR1, CFP1</td>
<td>CMDK1, CMGE2, CMGR1, CMP1</td>
</tr>
<tr>
<td>Academic spin-off</td>
<td>CTDK1, CTGE1, CTP1</td>
<td>CFGE2</td>
<td>CMGE3</td>
</tr>
<tr>
<td>Total (N=27)</td>
<td>9</td>
<td>10</td>
<td>8</td>
</tr>
</tbody>
</table>

For allowing comparability of the results, the common methodological basis of all case studies was a standardized questionnaire and a structured interview guideline. The items of the common interview guideline included the following dimensions: general information about the entrepreneur and the firm, the entrepreneurial innovation process, the determining factors of this process, the outcome and performance of this process. On the basis of the structured interview guideline, one or two interviews per case study were conducted with company experts from different hierarchical levels and from different functions. Normally, the managing director or the founder, resp. the owner of the firm was interviewed. The expert interviews were often supplemented by a company tour and the analysis of accessible company documents. The data collected were summarized in case study reports based on a standardized structure. These reports were evaluated systematically by a qualitative content analysis.

*The abbreviations of the cases may be clarified by the following example: CFGR2 stands for Case, Food, Greece, Case Study No 2.*
4.2 Empirical types

On the basis of the case study results four types of KIE processes in LMT industries will be outlined in the following. The generation of these types is based on the dimensions of the analytical framework (see section 3). These types differ in two respects: Firstly, each KIE type represents a specific expression and combination of the various dimensions of the framework. Secondly, the types differ due to the most influencing factor; i.e. one of the dimensions of the analytical framework proves to be the main determining factor for resp. the KIE type. Hence, the description of the different KIE types is centered on two features: Firstly, the dominant determining factor leading the course of the KIE process. Secondly, complementary factors which are – in comparison - of less importance. Thirdly, further common intervening factors have to be taken into consideration. As outlined above, these intervening factors cannot be regarded as core dimensions of KIE, rather they may modify the KIE process in a general way.

The estimation of the importance of the various influencing factors for the analyzed KIE processes is based on a combination of several indicators referring to conventional methodological steps of qualitative analysis (Kelle and Kluge, 2010): Firstly, the direct statements of the interviewees and their self-estimation of the their entrepreneurial activities have been regarded as the main indicator. Secondly, a comparative “cross examination” of the various data of the whole case study analysis (standardized data, interview results, secondary sources as documents) and their “plausible” interpretation had been regarded as a second important indicator. Thirdly, the criterion whether the distinction between the different KIE types is convincing and clear-cut has to be regarded as a further indicator for the estimation which factors are utmost, minor or only intervening importance for the KIE process. Basically, the KIE types have to be regarded as empirical types. Their development is data-driven but also guided conceptually.

5. Empirical findings: four typical patterns of KIE-LMT

Bearing this methodological approach in mind, four types of KIE-LT can be distinguished on the basis of the case study findings: a demand-driven type, a science- and technology-driven (S&T-) type, a capability-driven type and a fourth type termed competitive pressure (see table 2). These four types will be described in detail in the following sections.
Table 2: KIE-LT types and classification of case study companies

<table>
<thead>
<tr>
<th>KIE-Modus</th>
<th>Type</th>
<th>Market-driven</th>
<th>Technology-driven</th>
<th>Capability-driven</th>
<th>Sectoral pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corporate venture</td>
<td>CMDK2</td>
<td></td>
<td>CFGE3</td>
<td>CFDK2</td>
<td>CMGE1</td>
</tr>
<tr>
<td></td>
<td>CTGR1</td>
<td></td>
<td></td>
<td>CFGE1</td>
<td>CTGE3</td>
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<tr>
<td></td>
<td>CFRG2</td>
<td></td>
<td></td>
<td>CTGE2</td>
<td>CTGR2</td>
</tr>
<tr>
<td></td>
<td>CFRG3</td>
<td></td>
<td></td>
<td>CMP2</td>
<td>CFDK2</td>
</tr>
<tr>
<td>Industrial start-up</td>
<td>CMDK1</td>
<td></td>
<td>CFP1</td>
<td>CTDK2</td>
<td>CMP1</td>
</tr>
<tr>
<td></td>
<td>CFDK1</td>
<td></td>
<td></td>
<td>CFRG1</td>
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<td></td>
<td>CMGR1</td>
<td></td>
<td></td>
<td>CMGE2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CTP2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Academic spin-off</td>
<td>CTDK1</td>
<td></td>
<td>CFGE2</td>
<td></td>
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<tr>
<td></td>
<td>CFGE2</td>
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<td></td>
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<tr>
<td></td>
<td>CMGE3</td>
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<tr>
<td></td>
<td>CTGE1</td>
<td></td>
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<tr>
<td></td>
<td>CTP1</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Total (N=27)</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

5.1 Demand-driven

5.1.1 Market opportunities as determining factor

This type of KIE-LMT is characterized by the fact that its KIE-processes are mainly driven by market opportunities. This means that new market segments emerge due to an increasing variety of customer demands or that already existing and so far unexploited market segments are tapped. Nine of the examined case study companies can be regarded as this KIE type. Five of these are corporate ventures, i.e. enterprises with extended business activities and four are start-up companies. They come from all three examined branches. There are no case study companies which can be characterized as academic spin-offs. It may be assumed that the identification of new market opportunities is easier for established companies or industrial oriented entrepreneurs compared to entrepreneurs stemming from academia who are only loosely coupled with markets and customer demand.

The common feature of these market opportunities is that they usually do not constitute an element of traditional LMT industries; instead they tend to be of global character and are sources generally applicable knowledge beyond the specific sectors LMT situation. They offer new sales opportunities and high profits compared to the established restrictive sectoral market situation of the individual LMT firms. The empirical material shows that in many of the examined cases the new market opportunities resulted from socio-structural changes, in particular changed ways of life, new role structures, and – hence – new customer preferences. Outstanding examples for this are changed customer preferences with regard to foods and eating habits as well as a notable increase in demand for sophisticated convenience products or functionally sophisticated textiles (CFGR2; CFDK1; CTGR2). Moreover, in two cases the market opportunities resulted from direct customer requests and the therewith associated innovation impulses. Thus, a Danish manufacturer of sintered components reported that the development process
for the innovation was triggered by a customer who wanted to make wear plates from a new material. The customer’s role in the development of the new product was to motivate the company to start testing and prototyping different material blending (CMDK2).

All in all, the companies investigated are exposed to a significant “market pull”, which offers excellent prerequisites for the successful market launch of new products. Furthermore, new market opportunities were to some extent also accelerated by political and institutional influences. Thus one of the examined companies profited from the liberalization of the national telecommunications market which opened up a completely new market segment for newly developed technical components for communication systems (CMGR1). In other cases, stricter environmental protection regulations influenced indirectly customer preferences (CMDK2).

5.1.2 Complementary factors: transformative capabilities of the actors

As the research findings show, at the level of the individual firm and/or entrepreneur, the existing stock of firm-specific knowledge and set of capabilities to acquire new knowledge and to combine existing and new knowledge to a new level of knowledge plays an additional and indispensable role for this KIE type. To begin with, the research findings show that a key prerequisite for this is a broad firm-specific knowledge base regarding the specific situation of the firm and the own achievement potential. This is essential to be able to evaluate the extent to which the respective companies can take advantage of market opportunities. In all studied cases, this knowledge base comprised a high degree of accumulated knowledge about and manifold experiences in markets, management and organizational issues as well as the potentials of the given technology. This knowledge base is only to some extent the result of own research efforts in in-house R&D departments (CFGR3). In fact, it is to a high degree of practical nature. In the case of the established companies, it was acquired in the running process and in the case of new foundations it is the result of previous business activities. A typical example for this is the foundation of a food business with convenience and bread products (CFDK1). The founder had acquired the necessary management and technological skills during his earlier business activities for industrial bakeries.

In all of the examined cases belonging to the market-driven type of KIE, the capability to transform and absorb external knowledge proved to be of utmost importance. Firstly, the company’s ability to manage and effectively co-ordinate network relations across company borders with other companies within the value chain, research institutes and universities or specialized consultants, is a central precondition for successful KIE LMT. According to the research findings, the co-operation with customers or potential customers and with competitors too proved to be of great significance in these cases (e.g. CMGR1; CMDK1). Evidently, these co-operation relations are the precondition for the ability of enterprises and founders to gain the necessary knowledge about the given market. In addition, co-operation relations with technology suppliers from other sectors, such as machine manufacturers or research institutions,
also played a large role for the realization of planned innovations. These relations enabled the companies to obtain the necessary additional technological and scientific knowledge, e.g. new machine designs, new materials or design competencies.

Secondly, the companies had to be able to synthesize and combine the available and the new knowledge if they wanted to profit from the given opportunities. In this regard, the established firms point to an established learning culture or to very open organizational routines that facilitate the integration and utilization of new knowledge (CMDK1; CTGR2). This specific capability of the actors can be termed as “bricolage” capability, i.e. the ability to synthesize knowledge from many fields and hence to derive long-term company goals.

In a nutshell, knowledge intensification in the examined enterprises stands for a considerable expansion of the local knowledge base, primarily by means of referring to generally applicable knowledge about markets and application possibilities of new products beyond the given sectoral constraints.

5.2 Science & Technology-driven

5.2.1 Science and technology as determining factors

This type is characterized by the fact that scientific and technological opportunities and the interlinked generally applicable knowledge are the main driving factor of the KIE-process. These opportunities facilitate the development of new products or processes that open up possibilities for overcoming the restrictive LMT situation and for gaining new business perspectives. One can speak of a situation that can be characterized as “technology push”: The entrepreneurial activities of this type fall back on technologies that are globally available but which application is completely new to the LMT industry. Seven of the examined case study companies can be assigned to this type. The large majority of six companies includes newly founded firms, some as start-ups but most as spin-offs of scientific research (table 2). This distribution is quite obviously no coincidence. Newly founded enterprises normally aim at the implementation of technological opportunities that are new in relation to the established technology paths. The empirical evidence shows that the examined enterprises drew on new and above all obviously utilizable technological opportunities. Thus the start-ups of the textile industry used the opportunities of electronic technologies, resp. of new fiber technologies to combine these with traditional textile and clothing concepts and, by way of example, to develop smart textiles. The situation in the examined companies from the food industry is comparable. These companies drew on globally available research findings as knowledge about the use of eatable films in foodstuffs, knowledge about fruit drying and methods of a specific drying technology. The importance of globally available technological opportunities is plainly demonstrated by the example of a German metal start-up. Its foundation is based on the use of a pro-
cess technology that has been available for a long time, a specific welding technology, by means of which the scope of applications of established welding technologies could be significantly expanded.

5.2.2 Complementary factors: technological knowledge of the actors and new market niches

Following the case-study results, this type of KIE activities is also to a certain extend based on a sound technological knowledge which the founders of the academic spin-offs acquired in their previous scientific fields of work. This factor can be classified as a complementary factor for this KIE type. A German spin-off company that developed systems for the drying of fruits is a good example for this: Both founders had gained great expertise and experience with fruit drying in general and the solar drying system in particular during their times at the university (CFGE2). Similar evidence can be found, for example, in the case of a start-up metal company that developed new welding technologies. Here, the precise knowledge of traditional welding technologies and their possibilities and limitations was cited as an essential precondition for the innovations.

Another essential influencing factor is the extension and intensification of this knowledge base by means of co-operation relations with external partners. The enhancement of application-oriented technological knowledge and a broadening of the product-field-specific (sectoral) knowledge is an important objective of these cooperative activities in which the often technology-savvy founders are not well versed. Especially the examined start-ups cultivated close formal and informal co-operation relations with diverse organizations from various fields to obtain the necessary basic knowledge for the active business. The missing application-oriented competencies were e.g. obtained by the targeted recruitment of technology specialists such as electronic and software engineers. A prerequisite for this was the close contact to a scientific institute that trains such specialists (CTP1). In another case, the lacking process technology was secured within the framework of a close co-operation with a mechanical engineering company. The more practice-oriented business-competencies were acquired within the scope of network relations with suppliers of primary products, future clients as well as industry associations (e.g. CTGE1; CMGE3; CFGE3; CFP1).

The utilization of the technological opportunities was additionally spurred on by the given market opportunities and existing limitations of the traditional markets. Both factors urged the companies and the entrepreneurs to actually convert the pressing technological opportunities into marketable technologies. All in all, the market niches were new and resulted from new customer preferences that are generally due to changed lifestyles and high disposable incomes. In the cases of the start-ups from the textile sector, these changes entailed a growing demand for sophisticated and functionally enhanced clothing. In the case of the enterprises from the food industry, growing expectations with regard to healthy and high-quality products played an important role. In several cases, the emerging market opportunities can also be ascribed to stricter institutional-political regulations. Most notably, to be mentioned here are
strict EU standards regarding the shelf life of food, which has led to a growing demand for effective preservation methods.

To sum up, this KIE type is characterized by a process of knowledge intensification based on the expansion of the already available technologically oriented competencies by generally applicable, mostly scientifically created knowledge. Additionally, knowledge about new market opportunities beyond the specific sectoral situation is of importance for this KIE process.

5.3 Capability-driven

5.3.1 Company’s capabilities as determining factors

A third type of KIE-LT can be termed “capability-driven”. This type is not propelled by globally available market or technological opportunities; instead the driving forces for the innovative process can be primarily found at the local level of individual companies. On the basis of the ability to extend systematically the available knowledge stock, the company or the entrepreneur implemented an idea that was considered promising and thus lastingly improved his economic situation. In a nutshell, this is a classic case of the Schumpeterian entrepreneur. Of course, this KIE process cannot be seen in isolation from the overall situation, i.e. the given sectoral specific constraints and opportunities. Seven of the examined case study companies can be allocated to this KIE type. Four companies of these cases can be termed corporate ventures and three companies have the character of industrial start-ups (table 2). This empirical pattern is plausible because this KIE type is based on accumulated capabilities may it be within an established company or may it be based on the sector and product-field-specific experiences and knowledge of individual entrepreneurs. On the contrary, entrepreneurs from academia normally lack such capabilities.

In all examined cases, the starting point of these KIE activities was a profound knowledge base about the given industrial structures and the development potentials of the available technologies. In addition, the key actors have extensive management and organizational experience. Evidence shows that the corporate ventures in particular profited from the accumulated knowledge of the established enterprises. The KIE activities of a Danish dairy products manufacturer are an instructive example for this type. The precondition for these activities was a strong knowledge base about cream production dating back 20 years and sound knowledge about and experience with competitors, suppliers and customers (CFDK2). The situation in a more than 100 years old family enterprise, a brewery, is described in similar terms: It has outstanding brewery knowledge at its disposal (CFGE1).

Additionally, the interview partners of corporate ventures pointed almost unanimously to a long culture of innovation and an entrepreneurial tradition in their companies, which e.g. finds it expression in interdisciplinary development teams that continually drive innovations. In the case of the Portuguese metal ware manufacturer the innovation process was based on the existence of a qualified, interdisciplinary
team which acted in each of the projects or in consultations with clients, and which embraced the commercial, marketing, design, engineering, production, procurement and quality departments (CMP2). These activities were accompanied by continuous internal learning and training of the workforce. The interview results point to a similar situation in one of the two spin-offs. Here the “typical low-tech innovation culture: tinkering around” is highlighted by the founder (CMGE2).

5.3.2 Complementary factors: market opportunities

Market opportunities have to be regarded as an important complementary factor that the companies tapped by means of their KIE activities. These were often market niches beyond the sectoral and product-field-specific structures that developed in the context of changing market structures and demand preferences. Firstly, the growing demand for high-quality products has to be mentioned here. For the manufacturers of foodstuff and a textile manufacturer, this trend opened up the possibility of creating actively new market segments (CFGR1; CFDK2; CTDK2). Secondly, the opportunity of expanding given markets played an important role. In one of the examined cases, the company’s objective was to expand its regional market outlet in order to reach the national market (CFGE1) and in the other case the company aimed at entering foreign markets (CMP2). Thirdly, the innovation of the aforementioned mentioned textile manufacturer was aimed at the creation of new market segments; the conveyor belts with advertisements printed on them were intended for supermarket cash registers and thus created a so far non-existent field of application. Opportunities offered by globally available technologies have to be regarded as a further influencing factor; these are e.g. packaging technologies (CFGR1), materials technologies (CMP1; CMGE2) and transport technologies have to be mentioned which offer promising innovation perspectives in most of the entrepreneurial activities belonging to this KIE type (CFGE1).

In conclusion with regard to this KIE type, knowledge intensification signifies the use and expansion of the accumulated firm-specific knowledge base by a recombination of the elements on hand and the systematic integration of pertinent generally available knowledge about market opportunities.

5.4 Competitive pressure

5.4.1 Competitive pressure as determining factor

A fourth type of KIE-LT can be termed “competitive pressure”. The innovation driver of this type is the particularly strong competitive pressure of the specific sectoral situation. The representatives of the companies belonging to this type have pronounced knowledge about the economically and technologically severe situation of their firms. This knowledge is of firm-specific and sector-specific nature. The interviewees expressed this knowledge convincingly and emphasized that if the enterprises did not act or were not successful in their innovation efforts, their existence could be in jeopardy. Five of the examined case study companies belong to this KIE type. Four of these can be referred to as corporate ven-
tures; one of them can be regarded as an independently founded start-up (table 2). Similar to the demand-driven KIE type it may be assumed that the identification of a severe industrial situation is primarily possible for established companies or industrial oriented entrepreneurs compared to entrepreneurs stemming from academia who are only loosely coupled with the industrial situation.

If one summarizes the research material, two basic aspects of competitive pressure can be distinguished: Firstly, the overall economic situation is extremely difficult, due to the growing cost pressure by competitors from low-cost countries. As has been shown, this is a central feature of the whole LT sector with its mature technologies. This problem, however, proves to be particularly pressing in the case of the examined enterprises. Secondly, technological product or process bottlenecks are a weak point. These bottlenecks frequently result from new requirements on the companies that often thwart attempts to increase efficiency and lower costs. Or they hamper the further incremental development of products which is needed to help to secure the company’s market share. Both instances have to be resolutely tackled to avoid risky situations.

An example of a difficult economic situation is the situation of a German manufacturer of customized fireplaces and steel-made goods (CMGE1). The market situation was described as follows: “It is becoming thinner and thinner.” There was increasing competition from abroad and from bigger firms in general, which were able to provide cheaper products because of scale economies for this relatively simple kind of product, which, according to the interviewed manager, “anyone can build”. The company has depended on occasional orders from customers who need products at short notice. However, these orders are subject to high volatility. The firm has been in a permanent state of hustling for customers. Therefore, the management has been systematically seeking for possibilities to become more independent of this market segment. A further example is the very difficult situation of a Greek textile manufacturer, which was confronted with a highly internationalized and fragmented market and high competitive pressure (CMGR2). Apparently there were hardly any opportunities for innovation for specific market niches. However, the examined enterprise is an exceptional case within its sector, as it has been addressing this situation. Within the framework of a corporate venture, a new process for the dyeing and finishing of textiles was developed. This process was vertically integrated into the whole value chain. Therewith, this company could achieve a good competitive position despite the difficult situation.

The situation of an enterprise of the food industry that treats fruit and vegetables for the wholesale is an instructive example for a bottleneck trade (CFP2). Because of the growing quality requirements of the wholesale trade, the company was confronted with a high number of rejects, i.e. unmarketable apples. To avoid related losses due to this, the idea arose to use the apples of lesser quality for the production of apple juice in order to avoid costs and to establish a new product line. This situation is succinctly described by the interviewed company representative as follows: "Of course, the rationalization of the
company’s resources – namely, the fruit that couldn’t be commercialized – was the underlying motivation for the new business” (ibid.).

5.4.2 Complementary factors:

A distinct knowledge base and special innovative capabilities of the companies have to be interpreted as complementary factors also important for the success of initiatives to overcome the competitive pressure. For one of the examined cases (CMGE1), the interviewees pointed to a "typical low-tech innovation culture", on which these capabilities are based. It is characterized by incremental innovation activities during and besides the daily work, furthermore innovative ideas are developed by individual actors; structured and systematic search processes seem to be less common. For all of the examined companies, the case study findings moreover make the point that their management or founders have a good stock of knowledge- accumulated in the course of many years – about technological opportunities, the sales market situation as well as management requirements. This knowledge stock enabled them to systematically and purposefully establish co-operation relations with machine manufacturers, suppliers, marketing experts and other external partners as well as to integrate and use new knowledge.

Furthermore, one has to inquire the market opportunities that the companies opened up with their KIE activities and with which they could markedly improve their competitive position. According to the research material these opportunities arose solely due to generally emerging market trends. By means of their KIE activities, the enterprises tapped these markets and create their own market niches. A typical example for this is a German metal company that is described as follows (CMGE1): The firm benefitted from a discernible shift of interest in society towards environmental issues in general and green technologies in particular. With its early focus on these issues the company had a head start in comparison to competitors. Having the most efficient and environmental-friendly product has been a major sales argument for the firm.

In summary, as in the case of the other KIE types, knowledge intensification in this KIE type signifies the use and expansion of the firm-specific and product-field-specific knowledge base, most notably by purposefully rounding it off with generally applicable knowledge about new technologies and market opportunities.

5.5 Intervening factors

As outlined above (section 3), additional intervening factors have to be taken into consideration in order to analyze a KIE process as completely as possible. However, the empirical material indicates that there is no clear correlation between certain intervening factors and the various KIE types that have been sketched. In fact, such factors can only be identified on the basis of the whole research sample in a general perspective, i.e. they prove to be occasionally important for individual KIE cases. According to the empirical material, there are at least three factors of major significance:

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9 The findings of a project on innovation processes in low-tech industries support this thesis (Hirsch-Kreinsen, 2008).
First, the issue of funding and financing the KIE processes proved to be of great importance in nearly all cases, independently of the concrete KIE type. However no companies obviously suffered from a crucial lack of financial resources. Most of the KIE companies and start-ups investigated made use of internal funds to finance their activities. Some of the companies took out a loan for smaller parts of the needed funding (CMGE2). Only a few successfully applied for funding by the state or by public support programs. In fact, many of the interviewed company representatives emphasized that such programs have been not attractive for the companies because e.g. of the bureaucracy and the program manager’s lack of knowledge about the specific situation of LMT firms (CMP1; CTP1). These and similar comments refer to both national funding programs as well as European programs.

Second, for some of the companies, regional embeddedness seems to be beneficial for their KIE process. The local proximity to e.g. suppliers, scientific organizations or banks and investors makes it easier to gain new technological knowledge, additional capacities or financial resources. An example for this is the Portuguese firm from the metal working sector and its network with local “rivals” (CMP2). This local network has two functions: For one thing, the production capacities were leveled out between the different metal ware manufacturers; for another thing, this co-operation facilitated the opening up of “unfriendly” markets such as the Chinese market.

Third, there are also constraining conditions for the KIE process which can be summarized as follows: The interviewees, often from Southern Europe, referred to an “unfriendly environment for entrepreneurial activities” and the lack of a clear institutional framework promoting such activities; furthermore they highlighted the existence of many political and institutional obstacles (e.g. CTGR2). They also mentioned lacking support by industry associations and poor professional guidance by consultants (CMGE3). Furthermore, they criticized the limited or even lacking availability of venture capital that was needed especially in the high-risk initial phases of foundations (e.g. CFP1).

5.6 Outcome: Innovation

If one examines the innovations resulting from the various KIE processes more closely, a relatively clear-cut pattern can be identified. In two of the four outlined KIE types, viz the types market-driven and capability-driven, innovations were found that can be referred to as architectural and modular (Henderson and Clark, 1990; see section 2.3). Measured by the existing situation of LMT sectors, these innovations seem to represent a completely new type of technology at first glance. At second glance, these new products were based on available technologies and corresponding components. Evidently, such an innovation type lends itself particularly well to new market opportunities. As these innovations built upon already available technologies to a quite large extent, the knowledge base and capabilities could be systematically introduced into and utilized in the innovation process. A good example for the KIE type

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10 There are of course national specific divergences which cannot be discussed in the context of this paper due to its limited scope.
demand-driven is the flexible process innovation of a Danish start-up from the food industry. Although this innovation is referred to as “unique” with regard to its flexibility, it is obviously a question of the recombination of already available machine technologies in principle (CFDK1). The innovation of a Greek metal company can be considered to follow a similar pattern: It is based on the redesign of an existing product technology to increase its efficiency as well as its flexibility. In doing so, they systematically made use of available technological components or changed already existing ones without changing the products as a whole or in their basic design (CMGR1).

In the case of the competitive pressure and science & technology-driven KIE types the situation has appeared in a different light. The innovations implemented within this context have at least a partially more far-reaching character, or, putting it tentatively: Measured by the traditional technologies of LMT industries, they approach the type ‘radical innovations’: Often a new dominant design of a product or a process can be discerned that results from the combination of various technological components. In the case of the KIE type technology-driven this is highly plausible. It seems obvious that the use of technological opportunities leads to completely new product and process technologies and that these are especially implemented in the context of academic spin-offs. Thus this type is usually characterized by the use of technologies that – though generally available – were not used before by LMT firms. As described above (see section 4.2), this involved IT and software components, the use of completely new textile fibers and the deployment of new process technologies. In relation to the structures of the previous technological development paths in the sector, these innovations have a fundamentally novel character. Moreover, in the case of companies that attempted to overcome a particularly strong competitive pressure this connection can be observed too. Apparently, they have only succeeded in doing so when they had opened up new fields of activity (CFP2; CTGE3; CMP1).

6. Conclusion

To sum up, it should be underlined that KIE processes in LMT industries usually occur without any major and targeted support of innovation policy at the national and European level. At best, traditional firms can apply for state-funded innovation projects which have a general character and are often targeted towards high-tech innovation activities. The opportunities for entrepreneurial processes in LMT industries are greatly underestimated. However, this situation could be significantly improved. The findings of this study point to several possibilities for policy measures which would foster KIE activities in LMT industries. These are e.g.:

- improving access to trans-sectoral knowledge especially for existing LMT firms and individual entrepreneurs with their often limited resources;
• improving the transfer processes of the globally available knowledge to the local knowledge stock of individual LMT firms and entrepreneurs;
• enhancing the local and firm specific capabilities to integrate and utilize new knowledge, e.g. by improving management competences, especially the capability to cooperate and network in a global direction;
• considering the framework conditions, i.e. the moderating factors should be the object of policy measures, in particular with respect to regional proximity and networking as well as the terms of corporate financing.

Without question, these policy recommendations are of major relevance for entrepreneurial activities in LMT industries. However, they need to be specified in further broad-based research on entrepreneurial activities in LMT industries. The outlined KIE types may be the starting point and the working hypothesis for further research. Additionally, a systematic comparison between KIE-LMT and KIE in the high-tech sectors will be of particular importance. The assumption is plausible that these differences may be only a matter of degree. One may speak of a spectrum with two extremes: On the one side KIE-LMT, on the other side KIE in high-tech, with a smooth transition in between the two ends. However, this comparative perspective has not been systematically applied yet and should also be a major issue of future research.

References


