Knowledge-Intensive Entrepreneurship in Low-Tech Sectors – Preliminary Hypotheses and First Empirical Evidence

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Contents

1. Introduction ............................................................................................................................... 3
2. What is Low-tech? ..................................................................................................................... 4
   2.1 Basic categories .................................................................................................................. 4
   2.2 The relevance of low-tech ................................................................................................. 5
   2.3 Differentiations .................................................................................................................. 5
3. Elements of KIE in low-tech .................................................................................................... 6
4. Building blocks of KIE-LT. .......................................................................................................... 7
   4.1 Innovation ........................................................................................................................... 7
      4.1.1 Architectural innovation ............................................................................................. 8
      4.1.2 Modular innovation .................................................................................................... 8
   4.2 Knowledge base .................................................................................................................. 9
      4.2.1 The company’s internal knowledge base ..................................................................... 9
      4.2.2 The company’s external knowledge base ..................................................................... 10
   4.3 Company capabilities ......................................................................................................... 11
      4.3.1 Synthesizing capabilities ........................................................................................... 11
      4.3.2 Organisational capabilities ......................................................................................... 12
      4.3.3 Design capabilities ...................................................................................................... 13
   4.4 Institutional conditions ........................................................................................................ 13
      4.4.1 Loose coupling with vocational education and innovation policy ................................. 13
      4.4.2 Tight coupling with the given economic and industrial structures ............................... 14
      4.4.3 Relevance of regional ties ........................................................................................... 16
5. Conclusion .............................................................................................................................. 16
References ......................................................................................................................................... 18

Preliminary note: This paper presents first conceptual and empirical considerations regarding the question what we can be understood by KIE in low-tech sectors. It does not present a conclusive argumentation. Some sections could not be discussed in detail due to still pending empirical findings. The empirical findings outlined here are based on the re-interpretation of available research results on innovation processes of enterprises from the low-tech sector. These results need to be complemented and modified by upcoming research findings from WP1.3 of the AEGIS project. The short conceptual reflections on KIE in low-tech are based on previous studies and are intended to trigger further discussion. They doubtlessly need to be modified and developed further. In general, this paper aims at developing a first draft for a framework of the line of reasoning.
1. Introduction

The starting point of this paper is the ongoing scientific discussion on knowledge-intensive entrepreneurship (KIE). The concept entrepreneurship includes the following basic and well-defined dimensions: First, the term entrepreneurship is linked to innovation and economic change; in this sense, entrepreneurship 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 (cf. Malerba, 2010). 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. Third, entrepreneurship is defined as a process. It includes all aspects such as decisions, perceptions, organizational steps, feedback loops etc. of an innovation process. Entrepreneurship is defined here as a process involving the organization of resources and the output of that process is an innovation. Furthermore, the economic value of entrepreneurship depends on the economic value of the resulting innovation (Audretsch et al., 2002: 157). Fourth, significant innovations can be implemented in terms of a start-up, a spin-off of an existing organization or within an established company.

What is important is that the term knowledge-intensity is strongly oriented towards the utilization of scientific and technological knowledge. In other words, R&D activities and the commercially oriented use of scientifically created knowledge are regarded as the main feature of KIE. Hence, the term KIE is narrowly linked to the discourse on the growing significance of knowledge in societal development and the emerging “knowledge economy”.

In this context, the concept knowledge-intensity 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 (for KIE of incumbent firms). 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 applied within the low-tech sectoral reference system of innovation. Knowledge-intensive processes can become necessary in the light of newly emerging problems due to global changes 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 prerequi-
site for knowledge-intensive entrepreneurship is the capability to question existing knowledge and to identify and acquire (new) relevant knowledge from other knowledge bases. It must be assumed that the path dependencies and institutional barriers to this are particularly high in low-tech sectors with distinct knowledge bases and technological development paths, all the more so for well-established enterprises in these sectors.

So far, the debate on knowledge-intensive entrepreneurship has mainly focused on new technology based firms or academic start-ups in high-tech sectors. Little attention has been paid to companies that do not conduct R&D and do not use scientifically created knowledge. Are these, by definition, neither innovative nor can they be regarded as KIE companies? Put positively, what does KIE mean in the context of low-tech sectors and which specific characteristics does it have?

On the basis of the state-of-the-art low-tech research, in particular the findings of the PILOT¹ project, a number of tentative thesis on KIE in low-tech environments will be formulated. These will be reassessed and specified in the further course of the empirical studies within the scope of the AEGIS project. On the one hand, they will relate to the various dimensions of KIE outlined at the beginning. On the other hand, they will specify the term KIE from a low-tech-specific or sector-specific perspective. The paper will look into this matter in more detail in the following steps: First of all a short outline of the term low-tech will be presented, after that first reflections on a concept of KIE in low-tech are following and first empirical illustrations of KIE on the basis of its building blocks are pointed out. Finally a conclusion with open questions within the framework of the research project is drawn.

2. What is Low-tech?

2.1 Basic categories

The term “low-technology” denotes those industrial sectors that 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”.² 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, mostly "ma-

¹ Cf. www.pilot-project.org
² 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, p. 108).
“industries such as the manufacture of household appliances, the food industry, the paper, publishing and print industry, the wood and furniture industry and the manufacture of metal products - such as the foundry industry - as well as the manufacture of plastic products 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).

2.2 The relevance of low-tech

The interest in LT industries is motivated by contradictory aspects: On the one hand, the socio-scientific and the public debate on the perspectives of modern societies is characterised by the perception that only the massive increase of research and development institutions and of innovations based on high-tech will in the long run safeguard jobs and wealth, given the growing global competition. The growing importance of knowledge work, knowledge management and knowledge-based organizations in the context of deeply changing social and economic societal structures is emphasised in unison. On the other hand, however, the surprising viability of the non-research-intensive industrial sector in the developed economies of the Western countries up to this day cannot be ignored. 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 accounts for only about 10%. ³

Not least because of the increasing scarcity of raw materials and high commodity prices, the maintenance and international competitiveness of low-tech sectors such as consumer goods and primary industrial products should be a major concern of national as well as of European economic and commercial policy to avoid too great a dependence on imports of these essential manufacturing goods.

2.3 Differentiations

As we know, the term low-tech does not sufficiently define the sectors in question. At least three aspects should be taken into consideration when dealing with low-tech companies and sectors in further research activities:

(1) Firstly, while this concept may be useful with regard to a first statistical definition, the term ‘traditional industries’ probably more appropriately specifies the industrial structure in question. In this sense, the above-mentioned industrial sectors are traditional industries. To underline this one has to add further

specifications, e.g.: These sectors are characterised by established technologies and production regimes. They have undergone a shorter or longer evolution, which resulted in the emergence of recognised standards, methods, and knowledge related to both products and processes. This is perhaps one of the most important reasons for the generally difficult competitive position of many of these industries in Europe: the basic technologies and procedures relevant in the sectors are well known and can often be easily copied by foreign competitors with a lower cost base. A consequence of the established character of the technologies is that the technological change is predominantly incremental. Radical innovations based on fundamentally new scientific findings or erratic shifts in buyers’ preferences can happen but are an unusual event in traditional sectors. This applies to both products and processes. Consequently, the growth rates in these industries are relatively low.

(2) Secondly, when speaking about low-tech, we have to differentiate between the sectoral and the company levels. On the sectoral level, we have typical low-tech branches (see above) characterised by a low level of R&D intensity. However, on the company level the situation is not clear at all. Empirical data show that there are low-tech companies (with a low-level of R&D intensity) in typical high-tech sectors such as the pharmaceutical industry or mechanical engineering and - vice versa - high-tech companies in typical low-tech sectors. These findings show that there are sectors with few and sectors with more low-tech companies, the latter being the above-mentioned low-tech sectors (cf. Kirner et al, 2007). Therefore the area of research of the AEGIS project should be stated more precisely as low-tech companies from a sector dominated by low-tech companies.

(3) Finally, one has to stress the fact that low-tech companies are to a large extent SMEs. Following aggregated data on company sizes and R&D intensity (CIS, 2004: p. 40), the LT sector in Europe mainly consists of small and medium-sized enterprises (SMEs); the same holds for Germany, in 2006 more than 50% of all manufacturing companies were low-tech companies (Kirner et. al, 2007).

3. Elements of KIE in low-tech

On the basis of the above KIE definition and first insights from the ongoing AEGIS project, elements of KIE in low-tech (in the following KIE-LT) can be preliminarily outlined; of course much more work is necessary to come to a valid concept of KIE-LT:

(1) Firstly, we speak of different modes of KIE-LT, i.e. how and where KIE-LT takes place: within already existing firms, or by means of the foundation of new companies of different provenance (academic or arising from existing firms).

(2) Secondly, we distinguish specific building blocks of KIE-LT; here we have to look at:
a) The **courses and types of innovation** which can be regarded as specific for KIE-LT and the determining factors of these specific courses of innovation; here we analyse empirically the specific innovation strategies of LT companies.
b) The specific **knowledge base** of KIE-LT which includes a company internal and external dimension; here we refer to different types of knowledge, in particular to the relevance of scientifically created knowledge and knowledge based on practical experiences.
c) The specific **company capabilities** as the prerequisites to utilize the available stocks of knowledge: in this respect we refer particularly to the existing organisational structures and routines of LT companies and the managerial competences and skills.
d) The institutional resp. external environment of the KIE-LT process, i.e. the degree of its institutional “embeddedness” and the supporting and/or restricting role of the institutional environment for the KIE-LT process.

(3) Thirdly, we tentatively assume that the concrete characteristics and combinations of the building blocks may vary according to the different modes of KIE-LT (e.g. start-up or established company).

4. **Building blocks of KIE-LT**

As a preliminary attempt to outline relevant aspects of a KIE-LT concept we will focus on the aforementioned building blocks. The empirical findings of the PILOT project are the main basis for this. The line of reasoning thus mainly refers to the innovation activities of existing companies.

4.1 **Innovation**

The main characteristic of knowledge-intensive entrepreneurship in low-tech sectors is the type of innovation pursued by low-tech firms; it should be non-incremental. *In fact, the innovation should not only be new to the firm but also new to the whole sector or technological field.* In other words, in the context of knowledge-intensive entrepreneurship we are looking for innovations that neither occur routinely nor are only based on existing firm-specific or sectoral knowledge. Radical innovations are not typical for this sector, as they seem highly unlikely in fields of traditional technologies. Following the well-known taxonomy of Henderson and Clark (1990) and empirical findings one can therefore conclude that two types of innovation can be regarded as typical for KIE-LT.

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4 Due to not yet available empirical findings this relation will be not discussed in the paper at hand.
4.1.1 Architectural innovation

This type of innovation entails the re-linking of components, while the knowledge of the single components remains the same. 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. In the process, the well-established technological development path is not left but often a remarkable flexibility is required with regard to the restructuring of organisational routines. Architectural innovation uses given technological core concepts and knowledge assets and develops these further within the framework of the chalked out development paths.

This type of innovation can be illustrated by an innovation strategy which has been termed as “customer-oriented strategy” (cf. Hirsch-Kreinsen, 2008): This innovation strategy 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. The enterprises pursuing this strategy belong to a relatively broad range of industrial subsectors. Examples for this strategy are company activities from the textile and clothing industries and from furniture and leather goods manufacturers whose product development is geared to anticipatable fashion cycles and 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 supplied office furniture products of a new, not previously produced type and who correspondingly diversifies his products. In various 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 for certain customers. And finally, there are reports on the growing significance of so-called B2B internet portals which speed up and simplify the contact with important customers. In general, the customer-oriented innovation strategy is a good example for the type “architectural innovation”. This strategy is based on the rearrangement of almost unchanged product components and units to (seemingly) new products and thus does not only meet special customer requirements but also opens up new market segments.

4.1.2 Modular innovation

Following Henderson and Clark (1990), modular innovations require new knowledge for one or more components, but the architectural knowledge remains unchanged. Empirically, this type of innovation refers to an innovation strategy which has been described as “process specialisation” (Hirsch-Kreinsen,
The enterprises pursuing this strategy belong to industrial subsectors with products 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 woodworking 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 the paper manufacture and the intricate processes in the food processing industry, in which technologically elaborate processes are continually being optimised and developed further. Furthermore, under these technical and organisational conditions, the safeguarding and constant improvement of the product quality is achieved quasi as a by-product. Apart from processes with a high technological level and automation degree, these innovation activities also comprise processes with relatively simple standard techniques which are continually being “cultivated”. It comprises both the ongoing technical and organisational optimisation of existing production processes and also their structural reorganisation on the basis of existing technologies.

In other words, individual components of the whole manufacturing system are continuously improved in order to overcome obstacles and bottlenecks of the existing system. However, the outcome is not only a marginal improvement of an already existing type of process technology but very often a structural change of the whole system. On this basis the respective companies are able to overcome existing technological routines and paths and to operate highly sophisticated systems.

4.2 Knowledge base

Another main building block of KIE-LT is the company’s internal and external knowledge base. Both knowledge bases constitute crucial stocks of knowledge.

4.2.1 The company’s internal knowledge base

For an analysis of the knowledge base of the enterprises discussed here, one has to assume that these enterprises pursue virtually no own R&D activities. It therefore stands to reason that formalised processes of knowledge generation and use only play an insignificant role and that instead innovation activities proceed in the form of “practical and pragmatic ways by doing and using“ (Tunzelmann and Acha, 2005: p. 417). In a general perspective, the knowledge that is relevant for KIE-LT shall therefore be regarded as application-oriented practical knowledge. Unlike scientifically and theoretically generated
knowledge that orients itself on criteria such as theoretical relevance and universality, practical knowledge is generated in application contexts of new technologies and obeys validity criteria such as practicability, functionality, efficiency and failure-free use of a given technology.

Both types of knowledge are, however, difficult to distinguish. Simplifying matters, theoretical and scientific knowledge in enterprises, for instance in the form of systematically acquired engineering knowledge, can primarily be attributed to research, development and construction processes while practical knowledge accrues in the context of ongoing operating processes. The term “practical knowledge” stands for a complex bundle of different knowledge elements that comprises both explicit, codified and formalised elements such as, for example, design drawing and requirement specifications for new products as well as, above all, implicit elements such as accumulated experience and well-established and proven and tested routines for solving technical problems. The latter are closely connected with everyday experience and processes of “learning by doing” and “learning by using” which constitute a typical individual but also collective form of acquisition of practical knowledge.5

An example for this is the aforementioned innovation strategy of process specialisation. On the one hand, the enterprises considered here make use of engineering knowledge that is incorporated and codified in the production facilities and their operating instructions, on the other hand specifications and ongoing intervention and adaptation measures are necessary. An indispensable precondition for this is the practical knowledge in various forms gained in the respective operative processes, 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. Process innovations generally take place in the context of the ongoing operative processes and are potentially initiated and at any rate pressed ahead with by the staff responsible for the ongoing functions, such as engineers, technicians, master craftsmen and qualified workers. Similar innovation processes which, for example, entail the stepwise introduction and adaptation of new production and logistics techniques under the direction of the management and occasionally with the active participation of the production personnel, are also observable in the case of the customer-oriented strategy.

4.2.2 The company’s external knowledge base

The acquisition and generation of innovation knowledge definitely does not only take place within the company. Instead, external knowledge sources prove to be essential for KIE-LT processes too. In any case, the knowledge of other firms, organisations and actors as well as the systematic use of this knowl-

5 Similar correlations are indicated by Nonaka and Takeuchi’s (1995) category “operational knowledge”, which describes the process of integration (“internalization”) of explicit and codified knowledge into ongoing operating processes that are strongly characterised by tacit knowledge.
edge for the innovation measures pursued plays a decisive role. This is true for both practical know-
edge and especially also for scientifically generated knowledge in various forms.
Examples for external sources, for instance in the case of the customer-oriented strategy, are the ex-
périence of long-time customers concerning new market and demand trends, the expertise of pertinent
consultants, or information about foreseeable market trends gained during fair visits. Furthermore, the
fashion-oriented design of products, e.g. of chairs, by external design agencies plays a far from mar-
ginal role for successful sales strategies. Further important external knowledge sources are machine
manufacturers and suppliers who provide theoretically and scientifically generated knowledge in the
shape of knowledge incorporated in production technologies and materials, which is often an essential
prerequisite for the innovation activities of process specialisation.
In sum, one main dimension of the knowledge base of KIE-LT can be characterised as “distributed
knowledge base” (Smith, 2003), that comprises the different forms of knowledge of actors who are inde-
dependent of each other and often come from different sectors and technology fields. The empirical find-
ings suggest that the main source for the knowledge generation of the KIE-LT lies here.

4.3 Company capabilities

Besides the company’s internal and external knowledge, the therewith correlated specific organisational
and personnel capabilities have to be regarded as main features of the organisational level of KIE-LT.
Following the available research findings (cf. Bender, 2005; Bender and Laestadius, 2005), the relevant
capabilities can be termed as “configurational capabilities”. They constitute an organisation’s enduring
ability to synthesize novelty by creating new configurations of knowledge from dispersed knowledge
bases, artefacts and actors. There are at least three aspects of configurational capabilities: synthesiz-
ing, organizing and designing.

4.3.1 Synthesizing capabilities

Success in innovation is, on principle, to a large extent based on the synthesizing competence of actors,
that is, on their ability to tap distributed knowledge and know-how from diverse areas and to recombine
them creatively. This may include knowledge embodied in hard- and software, it may be practical and
scientific knowledge, design competence, or expertise in logistics. It may also include combinations of
science-based knowledge with practical aspects and crafts as well as the combination of different sci-
etific disciplines. In practice, it means that the firm is able to identify propositional knowledge in terms of
technical concepts or technologies that are potentially relevant to the firm’s business and then is also
able to synthetically transform and rearrange the pieces of knowledge in a creative way. Furthermore,
there is a temporal aspect to these configurational capabilities: namely the ability to anticipate future cus-
4.3.2 Organisational capabilities

The second dimension of configurational capabilities – empirically closely interwoven with the first – is an organisational one. These organisational abilities facilitate the combination of elements of knowledge and technology but also the link up of actors who possess relevant knowledge, technology and competence. As is also shown by the findings of the PILOT project (cf. Bender, 2005) this holds for smaller KIE companies, which, due to their limited resources, are often not able to incorporate new knowledge sources by hiring specialists or by mergers and acquisitions. Hence, they have to organise effective distributed “repositories” of relevant knowledge. That is to say, configurational capabilities include the ability to efficiently provide for access to and use of distributed sources of relevant knowledge and competence. This holds true in many cases involving the ability to cooperate with external R&D facilities or design labs. It also comprises an organisation’s competence to manage logistics in a timely and flexible manner.

The capability to utilise knowledge is largely dependent on the routines and structures of the company organisation, for instance the division of labour mode, the prevailing communication and co-operation forms and the therewith connected qualification and personnel structures (cf. Henderson and Clark, 1990; Cohen and Levinthal, 1990). Concerning the different innovation strategies, however, only few distinct connections could be empirically observed: In some cases the 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 of the staff. In other cases, for instance in those of fashion-oriented clothing manufacturers pursuing a customer-oriented strategy, 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 over the course of the years. Besides the above-mentioned cases, there are also many enterprises in which innovation ideas resulted from random trial-and-error processes or could often also be ascribed to the ideas of individual managers, technicians or salespersons. Aspects such as sufficiently open channels of communication, some room to manoeuvre and specific slack times at least for certain employees, but also corresponding impulses and targets on the part of the management that aim at promoting the target-oriented mobilisation of the available knowledge, can be regarded as constituting crucial personnel and organisational conditions for the effectiveness of these practices.
4.3.3 Design capabilities

Design capabilities constitute the third aspect of configurational capabilities. Besides identification and synthetic configurations, which can be assigned to the process of sensing and sizing, the adjustment within more or less complex (technical) systems requires certain design competences and creativity. In particular, the innovation strategy of process specialisation is a convincing example for the relevance of these design capabilities. Of course, this act of creativity, i.e. configuring and modifying artefacts to meet certain needs and expectations, has no necessary relation to recent scientific advances. Thus, it is an important activity spanning the whole innovation process. The lack of design competences and resources has to be compensated by organising external sources or partners, in this case the above-mentioned organizational capabilities are called for.

4.4 Institutional conditions

A further building block of KIE-LT is the institutional resp. company external environment, i.e. the degree of its institutional “embeddedness” and the supporting and/or restricting role of the institutional environment for the process of KIE-LT. According to the innovation systems approach, this especially pertains to those socio-institutional conditions that are evidently linked to technology development and innovations. According to the available research findings first, contradictory, aspects can be outlined as follows.

4.4.1 Loose coupling with vocational education and innovation policy

All in all, the conditions of the labour market and the institutions of vocational education and training are of minor relevance for promoting KIE-LT. This aspect is particularly highlighted by the experiences of enterprises pursuing the strategy of process specialisation. These enterprises employ the most modern production technologies and thus need sufficiently experienced and competent manpower for the continuous operation of the often complex robotised lines. KIE leads to organisational changes such as hierarchy reduction, the introduction of teamwork and the deployment of qualified labour. The demanded qualifications that are, for instance, described with keywords such as communication skills and the ability to work in teams, are not always available on the labour market. The companies investigated in the PILOT project point out that the content of vocational training does not always correspond to the actual requirements of the new technologies and of the new organisation structures and that therefore additional and costly training courses and processes of continuous further training and education are often necessary.
For the enterprises pursuing customer-oriented strategies, the institutions of the labour market and of the system of vocational education proved to be of even less significance for their innovation ability. Many of the non-research-intensive enterprises bundle their internal knowledge in the hands of a few managers and experts while the majority of the employees are more or less semi-skilled workers. Obviously this precludes special recruiting or qualification problems and these companies are therefore virtually independent of processes of socially regulated qualification acquisition. Besides this, the formal vocational system encounters its limits when it comes to knowledge-intensive processes that imply the learning and creation of something new that is not yet institutionalized in the sectoral knowledge base and can therefore not be anticipated.

Similar aspects can be made out with regard to the importance of political-regulative stipulations for KIE-LT (cf. Jacobson and Heanue, 2005). Company representatives have repeatedly pointed to decidedly negative political factors such as high costs, particularly labour costs and taxes, or an inflexible and restrictive state bureaucracy. It has to be assumed that these conditions hamper KIE-LT in particular. For another thing, especially enterprises pursuing the strategy of process specialization have on various occasions highlighted the fact that they hardly benefit from the existing public promotion of technological innovations. Sure enough, these promotion measures are often laid out in a sector-unspecific way or aim at the support of research and high technologies and not at the specific concerns of low-tech enterprises, a circumstance that is 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 KIE-LT, insofar as they are generally directed at the improvement of the technological and economic conditions of industrial production.

The same can be observed at the level of EU-technology policy. Here the focus on research and high technology is even more pronounced than at the national level. This applies to the different EU-wide support programmes since the beginning of the 1980s as well as to a programme such as EUREKA (European Research Coordinating Agency) that is primarily geared to co-ordinating different national businesses and organisations. In either case, the objective is to promote R&D activities and to initiate as far-reaching basic innovations as possible and to leverage them. According to the available findings, non-research-intensive innovations, i.e. KIE-LT, are neglected in these programmes.

4.4.2 Tight coupling with the given economic and industrial structures

Given the described importance of the distributed knowledge base for KIE-LT, it is not surprising that the companies’ embeddedness in the economic and industrial structures around them in many cases proves to be a relevant condition for their ability to innovate. As already mentioned in the context of the
positioning of KIE-LT enterprises in the value chain, this concretely involves networking with “neighbouring” and “supporting” companies and organisations which, as the case may be, provide new technologies and knowledge (Porter, 1998). This applies, firstly, to many West European countries with their pronounced concentration of suppliers, as this allows manufacturers - depending on their innovation and production requirements - to change suppliers more easily than in less industrialised countries and thus to adapt the value chain to new requirements flexibly and quickly. Particularly enterprises pursuing a customer-oriented strategy profit from this situation due to their market-driven flexibility needs. Secondly, this connection is of importance for enterprises with a process specialisation strategy. Close relations to the developers and manufacturers of production technologies are crucial for them. This holds good particularly if technical equipment is custom-designed, or if at least certain components and functions are adapted to the particular user needs. Naturally this presupposes relatively close co-ordination, communication and learning processes between the partners concerned.

Thirdly, service providers with specialised knowledge occasionally play an important role for KIE-LT. In this regard one can mention design companies that assume responsibility for parts of the product design, firms or institutes that have special competencies and facilities for quality tests or for solving special technical development questions, as well as market research institutions. One can often come across such co-operation relations in the case of the customer-oriented strategy. Sometimes specialised research institutes are also assigned development tasks such as, e.g., material tests or material calculation for the strategy of process specialisation, the design of installations. They furnish the engineering knowledge which is necessary for KIE-LT. And finally, the companies occasionally draw on consultants, for example, for solving problems of process development and optimisation. Altogether, the forms of exchange between the different actors of the distributed knowledge base can be very diverse. They range from a relatively anonymous market-regulated exchange to well-established and intensive co-operation relations. Furthermore, the tight coupling of KIE-LT processes with companies and organisations from research and development intensive sectors is crucial for these processes. This in particular concerns the above-described exchange relations with supporting companies as well as with the developers and manufacturers of complex process technologies, with the aforementioned service providers and also with research-oriented institutions which to some extent make new knowledge and technologies available in the context of close co-operative relations.
4.4.3 Relevance of regional ties

This tight coupling with the surrounding economic and industrial structures means that regional embeddedness of KIE-LT processes is, as the case may be, to a greater or lesser extent, relevant for their ability to innovate (cf. Garibaldo and Jacobson, 2005). Particularly for enterprises with a customer-oriented strategy, spatial proximity is regarded as important for 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. Furthermore, for a number of enterprises following the strategy of process specialisation, the proximity to the manufacturers of production technologies plays an advantageous role due to the mutual information and communication basis associated with it.

Moreover, 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, must be mentioned. 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 thus 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 results of KIE processes. For such actors and activities often-times provide knowledge that can initiate company learning processes that can lead to concrete innovation measures.

5. Conclusion

The outlined empirical findings can be summarised into a KIE-LT specific model. Theoretically, this innovation mode can be seen as the product of enterprise strategies that reflect the companies’ organisational capabilities and strategic priorities, which in turn interact with their economic and institutional environment (cf. Whitley, 2000). In this view, the special features of this model can be summarised as follows: The key innovation drivers are changing technological paradigms and changes in demand. These factors have to be regarded as essential (pre-)conditions for the KIE-LT process. Important criteria for successful KIE activities are the ways in which the respective companies deal with these requirements and potentials on the basis of their specific managerial and organisational capabilities. Key features are an in-house practical knowledge base in the context of a distributed knowledge base and the largely managerial-based capabilities to make use of and to expand this firm-specific knowledge base. In doing
so, the resources and capacities for strategic action are in the most cases limited, as the LT sector is generally dominated by small and medium-sized enterprises. Furthermore, a mostly loose coupling of the enterprises’ innovation capability with socio-institutional conditions prevails. In many cases, however, the networking with research-intensive sectors plays a comparatively central role for maintaining and expanding the innovation ability of these enterprises. Finally, the innovation types of architectural innovation and modular innovation can be regarded as an important characteristic of the KIE-LT process. These innovation types do not only comprise the ability to combine and recombine available technology components but also the capability of taking up, adapting and using distributed knowledge for novel problem-solving. Quite obviously, this allows enterprises to gain a considerable competitive edge in the face of an intensifying global competition, as these abilities render possible innovation strategies which enable the companies to leave chalked out step-by-step development paths in favour of a rapid product change. With regard to the generally increasing dynamics of technology, there is a growing need for LT companies to gain access to new knowledge and technologies and to improve their capabilities to integrate them into their innovation strategies. However, a lot of research questions are still open:

(1) Can the aforementioned building blocks and their specific features be regarded as sufficient for the analysis and the explanation of KIE-LT or should the analysis refer to more aspects?

(2) Are there differences between the various KIE modes concerning the relevance of the different building blocks? In other words, the above discussed building blocks should be linked to the different modes of KIE-LT, i.e. not only to company internal KIE processes but also to the foundation of new companies (spin-offs and start-ups). Our assumption is that the relevance of the different building blocks differs due to the specific mode of KIE-LT

(3) Moreover, the analysis of the determining factors of KIE within innovation systems of low-tech sectors (e.g. finance, market, technological or institutional opportunities and obstacles, etc.) regarding their differences compared to high-tech sectors deserves a more systematic empirical investigation.

And finally one has to ask for the differentiations between KIE-LT and KIE in high-tech sectors. These differences may be a matter of degree. One may speak of a spectrum with two extremes: on the one side KIE-LT, on the other KIE in high-tech with a smooth transition in between the two ends. However, this comparative perspective is not yet analysed and should be a major issue of the upcoming research activities.
References


