2 Conceptual frame of reference

Whether in case of independent new firms or corporate entrepreneurship, socio-structural conditions have an effect on the emergence of entrepreneurial activity. This correlation can be cross-disciplinarily found in economic and industrial sociology as well as entrepreneurship literature. That context matters for KIE just as well can be found, for instance, at Groen (2005) or Delmar and Wennberg (2010: 152): "[I]nitial conditions at birth both in the surrounding context and specifically at the firm level have a path-dependent effect on firm evolution." The industry's contextual influence on entrepreneurial decision making was generally stressed by Shane (2003: 118): "Many researchers have shown that the propensity for people to engage in opportunity exploitation through new firm formation differs significantly across industries." Thereby, Shane basically distinguishes between industry context "that favors opportunity exploitation through firm formation" (ibid.) and the one "that hinders opportunity exploitation through firm formation" (ibid.). The conceptual frame of reference seeks to find out more from existing deliberations about the relation between context and entrepreneurs that can help to understand and analyze the emergence of KIE in low-tech industries.

As a general starting point, the assumption of Malerba (2005a) and Malerba and McKelvey (2010: 8) is used that national and sectoral innovation systems (Chapter 2.1) play a decisive role in differently shaping the type and intensity of KIE. These systemic links between knowledge, innovation and entrepreneurship address a quite complex set of issues to be analyzed (Heidemann Lassen/McKelvey 2012: 54). For that reason, the effects of sectoral innovation systems on KIE have been less analyzed so far (Malerba 2010b: 13). In addition, Malerba demands "deeper analyses of the different dimensions of KIE and their links with innovation systems […] in particular agent-based models of KIE, innovation and industrial dynamics have to be produced." (2010: 24).

The following frame of reference addresses such a comprehensive consideration of KIE deriving relevant diagnostic questions from systemic, entrepreneurship and actor oriented institution theories. First of all, the concept of sectoral innovation systems (Malerba 2005a/b, Breschi/Malerba 1997) is introduced, which considers established knowledge and innovation practices as well as actors in a sectoral system (Chapter 2.1). For specifying the research dimension of the entrepreneurial level, Slavo Radosevic's concept of differentiated entrepreneurial opportunities is additionally applied (Chapter 2.2). This systemic concept links entrepreneurial activities with technological, market and institutional opportunities of a national innovation system. However, systemic approaches do not allow considering rare, deviating and creative activity like KIE. According to this theoretical perspective, entrepreneurs would not be

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able to conduct entrepreneurial activities successfully in case of insufficient entrepreneurial opportunities of the innovation system. But, especially this low entrepreneurial orientation must be assumed regarding the maturity and low technology intensity of low-tech industries. For this reason, the conceptual framework is extended by the concept of institutional entrepreneurship (Chapter 2.3). It emanates from willful entrepreneurs who are able to disengage from their social context and change it (DiMaggio 1988). Consequently, the systemic concepts are linked with an actor oriented institutional concept (Chapter 2.4) to explain the emergence of KIE in low-tech industries.

2.1 The concept of sectoral innovation systems

The sectoral system of innovation (SIS) approach is especially qualified for embedding KIE, because it applies a sectoral and broad multidimensional view on innovation (Geels 2004: 914; Pitt 2007: 127). Likewise, Malerba (2010b: 3 et seq.) emanates from influences of sectoral innovation systems on KIE that contribute at the same time to their transformation.

Basically, innovation system approaches were designed to “take all important factors shaping and influencing innovations into account” (Edquist 1997a: 2). Apart from focusing one-sided on R&D indicators and distant from any linear development model, the approach emphasizes the “social nature of innovation processes” (Wolfe 2011: 13). It is pointed to the systemic and interactive nature of relationships between science, technology and economy (Edquist 1997a: 1; Wolfe 2011: 45). The narrow view on innovation of the innovation paradigm from the 20th century is overcome by this systemic innovation approach. Freeman and Soete (1997) call it the innovation paradigm of the 21st century. Likewise, this perspective is called a “Neo-Schumpeterian perspective on innovation” (Wolfe 2011; Malerba/Orsenigo 1996) with which the low-tech approach of KIE from above is compatible. An innovation system is constituted by certain stability and components that are mutually related to each other “to develop, diffuse and utilize innovation.” (Bergek et al. 2005: 4). This interaction can happen in an intended as well as unintended way (ibid.). In order to reach their common goal of innovation, the system’s set of components “share a common boundary” (Wolfe 2011: 45).

Originally, the concept of sectoral innovation systems provides an analytical framework to grasp inter-industry differences in innovation that national or regional innovation system approaches cannot offer (Köhler 2008: 6). Close to the concept of technological systems, Breschi and Malerba (1997: 131) define a sectoral innovation system (SIS) as “a system (group) of firms active in developing and making a sector’s products and in generating and utilizing a sector’s technologies”. Distinct from national or regional system approaches, this analytical approach figures out “specific organizational and institutional features, which are the product of the historical path-

dependent trajectory along which the sector has developed." (Wolfe 2011: 48) This is based on the assumption that each sector has a specific (technological) knowledge base, learning patterns, actor networks and institutions (e.g. norms, standards, established practices, etc.) that shape a sector-specific mode of innovation (Köhler 2008: 6). For instance, innovation in the science-based pharmaceutical industry differs from the machine tool industry that is rather based on specialized practical knowledge (cf. Nelson/Winter 1977; Malerba 2004 in Köhler 2008: 6). Similarly, socio-technical theorists refer to sectors or industries as ideal types of artificial categories and consider them as "sozioökonomische Felder mit distinkten Regelungsmustern, Akteurfigurationen und Interaktionsbeziehungen, die sich um einen definierten ökonomischen Leistungsbereich […] konstituieren."[11] (Dolata 2011: 18). Malerba (2004: 9) terms an industry as "a set of activities that are unified by some related product groups for a given or emerging demand". With regard to the sector's boundaries he emanates from dynamic and fluent boundaries (Malerba 2005a: 385). Additionally, it has to be pointed out that in a sector different innovation systems can coexist related to different product groups (ibid. 387). Consequently, this framework is understood as an analytical construct (Bergek et al. 2005: 3).

Following Malerba (2005a), the main analytical dimensions for building a systemic sectoral framework are knowledge and technological domain, actors and networks as well as institutions. These dimensions can be found again in the socio-technical perspective that considers industries embedded in specific economic and technological core structures and core actors, which in turn are shaped by institutions like social conventions and routines, for example (cf. Dolata 2011: 18. et seq.).

Next, the different dimensions are presented in more detail in order to determine the characteristics of a low-tech institutional environment for KIE.

2.1.1 The knowledge dimension

Malerba conceptualizes a sectoral system referring to the knowledge dimension as "the collection of economic activities organized around a common technological or knowledge base in which individual enterprises are likely to be either actual or potential competitors with one another" (Malerba 2004: 428). A sectoral knowledge base describes a certain set of shared knowledge by the industrial actors of this sectoral system. The SIS can differ to other sectoral systems in *knowledge domains* and technological regimes (Malerba 2005a: 385). There are, for example, industries where science is the key driver of knowledge production, while other industries are determined by improvements and learning by doing (ibid. 387). Furthermore, Malerba basically distinguishes knowledge domains that are based on specific scientific knowledge and technological regimes for innovation activities and such domains that

[11] ... socio economic fields with distinct pattern of regulation, actor's figurations and interacting relations that are constituted around a defined economic field of performance (translated by author).

address customer specific applications (ibid.). In other words, variances are related to specific types and applications of knowledge.

Furthermore, an SIS can be specified by prescribing the accessibility, opportunity and cumulativeness of knowledge (Malerba 2005a: 389). Regarding the access to knowledge, different *opportunities* can be assessed. There are opportunities to gain knowledge from the industry, but also from outside the industry. Gaining knowledge from outside the industry depends on the one hand on the level and origin of scientific and technological opportunities and on the other hand on the firms' perception of technological domains and learning regimes (ibid.). Thereof, the sectoral environment can determine firms in terms of human capital with certain skills or in terms of scientific or technological knowledge from non-profit organizations. Scientific breakthroughs can be considered as an example for sources of such technological opportunities. In other industries, users or suppliers as well as improvements in R&D or technical equipment can be sources of technological opportunities (ibid. 388; 2006: 27). Beside the accessibility to opportunities, different sources of cumulativeness of knowledge are distinguished. Cognitive learning processes and organizational capabilities as well as market feedbacks are considered as sources for accumulating knowledge (Malerba 2005a: 388). Here, firm-specific capabilities are regarded as "highly path-dependent" (ibid.). Altogether, huge sectoral differences exist regarding science, technologies and knowledge bases that condition opportunities for innovation and built a varying institutional environment (cf. Malerba 2006: 23).

In the last decades, knowledge has gained a lot of attention from evolutionary and economic researchers that lead to the debate on the knowledge economy. Along with this went the observation of a discontinuous change in knowledge accumulation and distribution processes that have "redefined existing sectoral boundaries, affected relationships among actors, reshaped innovation process, and modified the links among sectors" (Dosi 1997; Lundvall 1992; Lundvall/Johnson 1994; Metcalfe 1998; Nelson 1995 in Malerba 2005a: 387). Exactly this development can be considered as a new chance for the matured low-tech sector as well as for knowledge-intensive entrepreneurial activity in these industries.

In the case of established industries, Robertson and Smith (2008: 101) have referred especially to distributed knowledge based outside the firm and industry. Similarly to Malerba's argument that a technological regime and opportunities can exceed a sectoral innovation system, Robertson and Smith argue that relevant knowledge for an industry can be "distributed across a range of technologies, actors and industries." (ibid. 100) Especially firms in low-tech industries are said to rely on such distributed knowledge bases across industries to keep up in innovation and competition (ibid. 101 et seq.; Hirsch-Kreinsen et al. 2006). Coming back to the required comprehensive analysis of the social structuring of processes for *knowledge creation* (Deutschmann 2008: 108) the question is, how well knowledge is combined and diffused in low-tech sectoral innovation systems (Bergek et al. 2005: 9). Moreover, which knowledge processes might have changed in the last decades. Following the dynam-

ic perspective of SIS concept identified patterns of a system cannot necessarily be considered as optimal (ibid. 14), because a system usually cannot immediately react and adapt to change. Changes in the sectoral knowledge base can have consequences for the organization of innovation and on sectoral boundaries (Pitt 2007: 127). They stimulate new actors "to complement the existing knowledge base and knowledge obsolescence produces changes in industry leadership" (ibid.). Hence, the SIS approach is not only useful to describe established practices for understanding KIE's deviation from it but also dynamics of the innovation system. The SIS analysis can also give first hints for structurally upcoming entrepreneurial opportunities in a matured industry.

Christine Anne Pitt (ibid.) concludes from the relevant, interdisciplinary distributed knowledge bases for innovation the importance of diverse actors' interaction because of their "complementary resources and competencies" (ibid.; also Wolfe 2011: 43). This leads over to the next analytical dimension of actors and networks.

Diagnostic questions concerning the knowledge dimension:

- *What are the knowledge domains of the industry?*
- *What kind of opportunities for innovation do they offer?*
- *How are the relevant sources of knowledge accessed?*

2.1.2 The actor dimension

At the centre of the SIS concept are companies producing products/components from the same product group (Breschi/Malerba 1997: 131; Malerba 2004: 9; Wolfe 2011: 48). However, an SIS is composed by heterogeneous actors (Malerba 2005a: 385). For that reason, Malerba points to consumers, entrepreneurs, users, suppliers, financial institutions as well as to non-profit organizations like universities and scientists, government agencies and industry associations. All those actors can differ in their importance and meaning to the system (ibid.).

Firms play a key role for the creation, adaptation and use of new technologies (Malerba 2005a: 390). Basically, it is assumed that firms of an industry use similar technologies and processing methods with common, related knowledge bases (ibid.). It is taken at a basis that these firms are embedded in the same institutional context and share common organizational and behavioral characteristics and learning patterns (Nelson/Winter 1982 in Malerba 2006: 23). Accordingly, firms from the same industry have several characteristics in common, but at the same time they can be considered as heterogeneous (Malerba 2005a: 385). This heterogeneity is manifested in firms' specific beliefs and expectations, their objectives and *competences*, or in

their organizational form. Low-tech literature (Kirner et al. 2009a: 447; Som 2012) also addresses this heterogeneity. There is a considerable mix of low-tech and high-tech firms within low-tech industries, but also low-tech firms exist within high-tech industries (Kirner et al. ibid.). This insight is an important premise to explain the emergence of KIE in low-tech industries as such ventures or innovators might differ from the majority of low-tech firms.

Generally, firms are supposed to permanently accumulate knowledge and learn. System innovation theorists like Bengt-Åke Lundvall or Charles Edquist especially emphasized inter-organizational learning for innovation (Lundvall 1992: 1; Edquist 1997a: 4). This was based on the supposition that firms do not innovate in isolation (Edquist ibid. 7). With this perspective, the shortcomings of the corporate view on innovation (paradigm of the 20th century) are overcome. But the focus on learning organizations is not sufficient to identify and explain the emergence of KIE.

Beside the industry's key actors, suppliers and customers can be important for such inter-organizational interactions for innovation. They are supposed to contribute to the boundaries of the sectoral innovation system while steadily influencing them as well (Malerba 2005a: 385). Universities – already indicated as sources for technological opportunities – can be another relevant actor. They generate scientific knowledge that contributes to technological change and are therefore often considered the main source for innovation (Malerba 2005a). Additionally, universities are responsible for the education of R&D staffs in firms and scientists carrying out patents later on (Malerba 2005a: 391). For specific industries like biotechnology or electronic industry, they are also regarded as incubators for new firms (ibid.). Apart from this, *entrepreneurs* are not especially treated as actors in Malerba's SIS concept (2004; 2005a/b; 2006).

The role of financing organizations in an SIS differs related to the developmental stage of the industry. Here, it is referred again to the industrial life-cycle concept. "When industry matures or large firms are relevant, capital constraints become lighter and much investment is self-financed." (Malerba 2005a: 391) In the case of new industries, emerging firms are usually weakly positioned in self-financing so that venture capital firms play a significant role (ibid.). This has also been indicated in the literature review of KIE (cf. Lenzi et al. 2010; Ben-Ari/Vonortas 2005; Malerba 2010a/b). Pitt (2007: 126) refers to the relevance of different actors with regard to the stage of the industrial life-cycle. "As sectors respond to change, there is a tendency towards greater heterogeneity of actors. New categories emerge to assume new roles in the organization of innovation activities" (ibid.).

The "nature of systemic interaction between key actors" (Wolfe 2011: 43) builds another central point of the SIS concept (ibid: 48). Beside the indicated cooperative and competitive relationships (Malerba 2005a: 385; Breschi/Malerba 1997: 131) also *interaction processes* of vertical integration, formal and informal interaction between profit as well as non-profit organizations are considered (Malerba 2005a). For indus-

tries where the knowledge base is becoming more scientifically based, interactions with scientific organizations will become especially vital for firms (Pitt 2007: 127). This presupposes the firms' ability to effectively interact with such actors (ibid.).

Finally, the SIS approach is not geared towards sheer market based exchange relations. It is "composed of webs of relationships among heterogeneous agents with different beliefs, goals, competences, and behavior, and these relationships affect agents' action." (Malerba 2005a: 392) Accordingly, Malerba applies a relational, network based perspective for determining the structure of an industry apart from common industrial economics (ibid.). This way, he takes account of networks as a source for innovation for the integration of distributed complement knowledge, capabilities and specializations.

Diagnostic questions concerning the actor dimension:

- *Who are the actors mainly involved in innovation activity, knowledge production and technology development?*
- *Can entrepreneurs be identified among the innovators of the SIS?*
- *Which dominant competencies of the innovators can be identified?*

2.1.3 The institutional dimension

The actors' behavior and interactions are enabled by institutions – the third analytical dimension of the SIS conception. Broadly institutions are understood as norms, routines, common habits, established practices, rules, standards, laws and others (Malerba 2006: 29; Edquist/Johnson 1997). Apparently they can exist in varying industry-specific forms and influence the SIS in different ways (Bergek et al. 2005: 13; Pitt 2007: 128). Such effects can be characterized more or less binding or enabling and at a formal or informal level (Malerba ibid.). Innovation system theorists acknowledge, for example, that a complex set of non-market institutions determine innovation and market forces of an industry (Edquist 1997a; 2005; Soete et al. 2009 in Wolfe 2011: 43). Analysts need a broad perspective to identify the relevant institutions (Bergek et al. 2005: 8). This might explain that the "study of the role of institutions in sectoral systems is still considered to be in its infancy." (Pitt 2007: 128)

In turn, institutions can be shaped through interactions among agents as a reciprocal process (Malerba 2005a; Pitt 2007). "At the sectoral level, these specific institutions may arise due to the planned and deliberate actions of firms or other organizations through such means as industry codes of practice." (Pitt 2007: 128) Likewise, institutions "may also emerge as unintended consequences of the interactions between

actors such as in the division of intellectual property rights in collaborative R&D projects." (Ibid.) *Industry-specific institutions* can differ from national institutions. Malerba distinguishes, for example, between industrial labor markets or industry-specific financial institutions (Malerba 2005a: 385/394.). Additionally, he assumes interrelations between institutions from the national and industry-specific level. National institutions may impede development or innovation in certain industries or lead to mismatches with industry-specific institutions and their actors (ibid.).

Again, entrepreneurial activity is not especially treated in the institutional dimension of Malerba's SIS concept (2004; 2005a/b; 2006). In general, the SIS perspective is more oriented to existing firms and their interactive learning activities (Wolfe 2011; Edquist 1997b) than to entrepreneurial activities. However, in his later work Malerba describes KIE as affected by innovation systems (2010b: 3 et seq.). But the role of industry-specific institutions in this respect has remained open so far. Other innovation system theorists have included the entrepreneurial aspect as institutions "enhancing entrepreneurship" (Edquist 2005) or "entrepreneurial experimentation" (Bergek et al. 2005; Carlsson/Jacobsson 2004). For Christine Anne Pitt and Susan Nelle, a key function of innovation systems is to facilitate and promote the entrance and survival of new firms and innovative SME (Chaminade/Edquist 2005 in Pitt/Nelle 2008: 9). Also, Anna Bergek et al. (2005: 15) emphasize the role of new entrants in their analytical considerations about dynamics of technological innovation systems. Behind these approaches lies the assumption that an increasing number of new entrants raise the chances for innovation and resource mobilization (Carlsson 2003 in Bergek et al. 2005: 15). The increase in actors in the SIS again entails that established firms have more opportunities to learn from entrepreneurial experiments and to contribute to knowledge development through knowledge diffusion (Bergek et al. ibid.). Moreover, new entrants are supposed to "influence the direction of search" (ibid.) and to contribute to the legitimization of upcoming new innovation systems (ibid.). This should be especially considered for KIE as the function of low-tech sectoral innovation systems' transformation. On the other hand, new firms usually face problems with their own legitimization and resources. Consequently, institutions that provide *legitimizing and mobilizing resources* as "free utilities" or "positive externalities" improve entrepreneurship in the innovation system (ibid.). This way, the belief in the growth potential of a new field can also be enforced.

It is more than worthwhile to investigate entrepreneurial experimentation in an SIS, because it depicts a specific form of knowledge development[12] (Bergek et al. 2005: 15). Entrepreneurial innovation is able to alter the established "direction of search"[13]

[12] Basically, Bergek et al. (2005: 15) consider R&D, learning from new applications, imitation and especially entrepreneurial experimentation as sources for knowledge development.

[13] Further mechanisms influencing the direction of search within the SIS: "different competing technologies, applications, markets, business models etc. These factors are not controlled by one organization. They represent the combined effect of: visions, expectations, belief in growth potential (demographic trends, climate debate, growth of SIS in other countries), actor's perceptions of the

(ibid. 10 et seq.) of the SIS and keeps it from lock-ins, since it secures the variety of new combinations. Following Bergek et al. (2005: 17), an innovation system "without any vibrant experimentation will stagnate". Entrepreneurial experimentation is to be distinguished from R&D activities, because it additionally reduces uncertainty effects of testing new technologies and applications of which some can fail and some succeed (Bergek et al. 2005: 15). Furthermore, they (ibid. 415 et seq.) explicitly emphasize that the variance of entrepreneurial experimentation is not exclusively achieved by new actors but by many different types.

> *It should be noted that the word 'entrepreneurial' does not refer only to new or small firms, but to the more general Schumpeterian notion of an 'entrepreneurial function' (i.e. making new combinations). This function may be filled by any type of actor, including large, established firms diversifying into the new technology. (Ibid. 416)*

This notion converges well with the preliminarily outlined approach of KIE in low-tech industries as corporate entrepreneurship.

Pitt and Nelle (2008) have used a broader term to link industry-specific institutions with entrepreneurial activity. They investigated the entrepreneurial orientation of the Australian red meat industry as a function of the sectoral innovation system to improve the innovativeness of this low-tech sector. Accordingly, the institution of *entrepreneurial orientation* determines "how problems and opportunities arising from changes in the external environment are perceived by the players in the sector. This, in turn, will determine how proactively the sector responds." (2008: 4) Thereof, the propensity of firms to engage in entrepreneurship reveals on the one hand their innovativeness, risk taking, and pro-activeness (Lumpkin/Dess 1996 in Pitt 2007: 118) as well as their educational and practical learning capabilities and motivation (Hindle 2002 in Pitt ibid. 119). On the other hand, these firm-specific aspects are influenced by the industry's "prevailing cultural perception regarding the social legitimacy of entrepreneurship" (Pitt 2007: 119). Entrepreneurial experimentation can be integrated in the term 'entrepreneurial orientation' as an appearance of the firms' entrepreneurial propensity. According to Bergek et al. (2005), likewise, institutions legitimizing entrepreneurship and mobilizing resources as free utilities can be considered as an expression of the sector's cultural perception of entrepreneurship.

In sum, the components' interplay within the SIS affects entrepreneurial firms. Their capabilities to sense and exploit opportunities arise from those interactions (Johnson/Van de Ven 2002; Shane/Venkataraman 2000 in Pitt 2007: 130). The entrepreneurial opportunities for innovation are distinguished from industry to industry due to the indicated industry-specific conditions (Malerba 2006: 23). Apart from the sectoral differences at all these levels, matured industries also need to undergo transformation processes in order to gain competitive advantages (Pitt/Nelle 2008: 2). Dynamics in sectoral systems are the result of co-evolutionary processes of their vari-

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relevance and different types of knowledge, regulation and policy, articulation of demand, technical bottlenecks, crises in current business" (Bergek et al. 2005: 16 et seq.).

ous elements, involving knowledge, technology, actors, and institutions (Malerba 2005a: 396). They "are likely to change over time" (Bergek et al. 2005: 14). This dynamic perspective implies that an innovation system is not necessarily optimal (ibid). The innovation performance of a system can be basically understood as a coordination problem of the system's components that need to be aligned.

In conclusion, although the "industry sector is not a common level of analysis in the study of entrepreneurship" (Pitt 2007: 133), it should have become obvious that innovation and entrepreneurship activity are "context sensitive" for the industry and firm level. The industry's entrepreneurial orientation affects how actors perceive entrepreneurial opportunities and how, in turn, their exploitation of opportunities helps the industry or SIS to proactively respond to changes (ibid. 149). A great advantage of these deliberations is that not only the sectoral structure and recurrent practices can be analyzed to understand KIE's deviation from it, but also the transformational situation of low-tech industries can be better mapped than by industrial life-cycle theory.

Diagnostic questions concerning the institutional dimension:

- *Are there any industry-specific institutions influencing the direction of knowledge and innovation development?*
- *Can any entrepreneurial orientation be assessed in terms of entrepreneurship enhancing institutions legitimizing or mobilizing resources?*

2.2 The concept of systemic KIE

Radosevic et al. (2011) are one of the first scientists linking KIE with the concept of innovation systems. Moreover, they apply an extended concept of entrepreneurial opportunities going beyond technological opportunities, which makes it valuable for the investigation of KIE in low-tech industries.

The integration of entrepreneurship and innovation system perspectives turned out difficult, because Schumpeter's entrepreneurship as well as the following person-centered view on entrepreneurship neglect systematic interrelations with the institutional environment (Radosevic 2007: 8), and on the other hand, innovation system theorists largely ignore routine-breaking entrepreneurial activity. They rather focus on institutions that stabilize individual behavior (ibid. 5). Against this background, Radosevic et al. (2011) developed a concept of entrepreneurial propensity of innovation systems. Their analytical framework seeks to explore the relationship between KIE and national innovation systems (NIS) as well as the systemic properties of KIE (ibid. 4).

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