Innovation in low-tech-considerations based on a few case studies in eleven European countries

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Innovation in Low-tech[1] – Considerations based on a few case studies in eleven European countries

1. Introduction

Quite contrary to a free lunch there are such things as conceptual undeads. The so called linear model designed to explain scientific and technological development is one of them. At the latest since the early 1980ies (e.g. Barnes & Edge 1982; Rosenberg 1982; MacKenzie & Wajcman 1985) has it been criticised as inadequate, simplistic, and empirically wrong. But nevertheless, it still plays a role in innovation policy and for some analytical concepts that describe technological development as a sequence of different phases too.

Some authors trace this model back to Schumpeter (e.g. Silverberg 1990) others (such as Stokes 1997, or Laestadius 2003) to Vannevar Bush's 1945 report to the US president where he characterised "basic research [as] the pacemaker of technological progress" (quoted in Stokes l.c.: 3).[2] Basically, the model assumes an unidirectional, causal and consecutive process which leads in three major steps or phases from fundamentally new scientific insights to useful technical products. According to this line of argument the foundations of technological innovations are laid through *basic research*. Results produced this way are then, and in another institutional setting, transformed into concepts for technical products and procedures by means *of applied research* and in a third phase these concepts are taken up in the *development and implementation* of novel technical procedures, devices and systems. The underlying idea is that in each of the subsequent phases results from the previous are delivered at well defined interfaces, taken up there by – in each case other – actors and treated following phase-specific values, procedures and criteria.

Over the years, we have witnessed manifold attempts to refurbish this model particularly by acknowledging the possibility of feedback loops between the allegedly distinct phases. But this did not really challenge the fundamental

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1 The terms low-tech (and medium low-tech) are used here according to the OECD (1994) classification. This definition is based on the relative expenditure of a firm or sector for R&D:

	Turnover : R&D
High-tech industries	*> 5%*
Medium high-tech	*5% – 3%*
Medium low-tech	*3% – 0.9%*
Low-tech industries	*< 0.9%*

2 Stokes indeed denies that Bush himself was a henchman of such a simplistic model. "Nothing in Bush's report suggests that he endorsed the linear model as his own." (Stokes 1997: 18)

idea: In the beginning scholars create new scientific knowledge. This is being further developed and transformed into technical concepts and those in turn into useful products. In other words, during the innovation process possibilities are used and advanced that new scientific insights disclosed in an earlier stage. If this is taken for granted new scientific knowledge appears to be not a sufficient but at any rate a necessary precondition for innovation. This is certainly not flatly wrong – as long as it is not supposed to mean that technological ideas and novelty do ultimately always result from scientific research.

It is definitely true that R&D is a way to generate very relevant conditions for and inputs into innovation processes. But it is also evident that innovation is by no means always rooted in scientific research (cf. Dosi 1988; Gibbons et al. 1994), there is a plethora of non-science-based innovations. The well-established discrimination between radical and incremental innovation is one way to conceptualise this. Incremental innovations are usually considered as improvements of existing products or methods that are scientifically rather unspectacular; they capitalise so to speak on proven scientific principles and established technological concepts. Radical innovations in contrast are based on a set of new scientific findings and principles. Hence, the difference is one of both the degree and the sources of novelty.

Notwithstanding this differentiation and due to severe methodological problems (cf. Laestadius 2003; Smith 2003) the innovative capabilities of countries or national systems of innovation (Lundvall et al. 2001; Pavitt & Patel 1999) are usually assessed primarily by means of quantitative output indicators; essentially the number of patents assigned – a measure which grasps incremental innovation inadequately – and/or the quantitative input indicator R&D expenditure relative to GDP. The second type of indicators privileges also a certain type of innovation namely radical innovation (cf. Smith 2003: 9) and moreover does it put at least implicitly the case for the much-maligned linear model just described. To some extent the latter holds true for much of the innovation research on the firm level too when the innovative character of a company is determined on the input side by the relative size of R&D expenditure and the number of employees with college or university degree (cf. Janz et al. 2004).

To state this critically is one thing. To develop a conceptual alternative is quite another thing. Because then you are immediately confronted with the need to develop new indicators – preferably measurable ones – to determine an actor's "innovation performance". I will leave aside the measurement problem (on that e.g. Grupp 1998: 99ff. and Laestadius 2003) and confine myself to presenting a few considerations on the possibility to conceptualise innovation when you focus on low-tech industries and therefore cannot use R&D expenditure as a meaningful indicator and do without counting patents too.

Following Jon Sundbo (while he is following Schumpeter) one can define innovation in a very general approach as the “introduction of new elements or new combinations of old elements in industrial organizations” for commercial use (Sundbo 1998: 1). The problem with a concept as broad as this is quite evident, it lacks discriminatory power. Seen this way virtually every change within an “industrial organisation” is an innovation as long as it is directed at commercial ends. In an attempt to gain some precision I would nevertheless like to start with Sundbo’s characterisation of innovation as an introduction or recombination of elements and link it to the differentiation between radical and incremental novelty.

Radical and incremental innovations have different effects on competition in an industry (see for an overview Henderson & Clark 1990: 9). The latter do by definition reinforce existing knowledge and competencies whereas radical innovations tend to destroy the value of established knowledge and capabilities. With the consequence that incremental innovation favours established companies in a field. The emergence of radically new products or principles on the other hand undermines incumbents’ competitive position because their experience and accumulated competencies do then no longer make for a headstart. At first sight the difference appears to be clear cut. “In some cases, however, new products can be assembled from existing components that qualify as radical innovation, despite the incremental innovation on the component level.“ (Katzy & Dissel 2001: 2) Where Sundbo speaks more generally of elements Bernhard Katzy and Marcel Dissel have tangible components of products in mind. And a specific mode of innovation. For they specify component competencies as opposed to architectural competencies. “Component competencies are characterized by a firm’s local abilities and knowledge fundamental to the day-to-day problem solving. This can be tacit knowledge developed by skilled engineers. ... Architectural competence basically refers to the ability to acquire and use component competencies for integration in new products and solutions.” (Ibid.) Reconsidered in this light the introduction of “new elements” complies with radical innovation and a recombination of elements as an either incremental or architectural one.

Katzy and Dissel’s conceptualisation follows a definition Rebecca Henderson and Kim Clark introduced a good decade earlier: “We define innovations that change the way in which the components of a product are linked together, while leaving the core design concepts (and thus the basic knowledge underlying the components) untouched, as ‚architectural‘ innovation.“ (Henderson & Clark 1990: 10) I will argue later in this article that a broadened understanding of architectural competence and architectural innovation is a useful starting point for the conceptualisation of no-science-based innovations. Beforehand I will present some results of a series of case studies conducted in a European research project on low-tech industries (the PILOT project)[3] to illustrate the empirical basis of the argument.

A clarifying annotation may be appropriate here to avoid a fundamental misunderstanding: The reason for the project's focus on low-tech and medium low-tech industries is that these sectors have been largely ignored by innovation policy and in innovation research too which is a problem because they can be crucial for innovation performance in a land or region. This thesis implies another one namely that high-tech on its own is probably not as crucial for innovation as it is usually taken for granted. But this does not mean to say high-tech is unimportant. It is beyond any doubt that excellent research and the transformation of research results into innovative products and procedures is of central relevance for economic success in the current societal conditions, often labelled as knowledge society. It would be difficult to find someone who challenges this statement in principle. We don't. But we do have severe objections against basic postulates and policy conclusions frequently associated with this diagnosis.

Whether the argument is brought forward in a reactive way describing the need for science based innovation as a necessary answer to constraints imposed by globalisation (e.g. Fagerberg et al. 1999) or in a more proactive way as a worldwide development model (e.g. Drucker 1994), its underlying logic is quite simple. It is based on the estimation that due to their high level of costs the wealthy nations can only be competitive when they produce highly sophisticated products that cannot easily be imitated elsewhere. And these are, the reasoning continues, goods that can only be created (from development to fabrication) when there is a high level of scientific knowledge and expertise available. Because in the current "knowledge based society" the spread of information and learning processes are performed ever faster this constitutes a constant pressure on the industries in the developed high-cost countries to permanently innovate. If such countries are to accomplish the challenges of global competition they must produce research-intensive products and high-technology. Sustainable are, thus, new, innovative companies and industries whereas mature, more traditional sectors loose their relevance and vanish by degrees.

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[3] "PILOT – Policy and Innovation in Low-tech. Knowledge Formation, Employment and Growth Contributions of the ‚Old Economy' Industries in Europe" is a transnational research project funded within the FP5 Key Action Improving the Socio-economic Knowledge Base (HPSE-CT-2002-00112). For details see www.pilot-project.org.

From this point of view some goals for innovation policy as well as for economic policy in general appear to be close to self-evident: Policy should support the emergence and growth of high-tech sectors where they do not flourish by themselves. Because these industries are, firstly, basically innovative and because they are, secondly, key sectors since their innovative strength will generate impulses and growth in other sectors too. This is why technology parks are set up with public money. Therefore the universities are asked to align with the needs of high-tech industries. And it is the rationale for the Lisbon goal to spend 3 percent of the Europaen Union's GDP for research and development in 2010 too.

Again: it would certainly be absurd to deny the relevance of high-tech industries for countries such as the members of the European Union. But one implicit basic assumption of the policy concept just outlined is rather problematic nevertheless. Namely the hypothesis that the ultimate source for innovation is scientific research and high-technology. This idea is disturbingly close to the linear model criticised above. It simply overlooks that a good share of technical innovations are not triggered by new scientific findings – presumably the majority of innovations.

2. Innovation in low-tech and medium low-tech companies (case study report)

The question how technical innovations are initiated and managed in firms with no or only little engagement in research and whether there is a low-tech specific mode of innovation is one of the issues the PILOT project teams investigated in a series of company case studies. With these studies we examined various aspects of the managerial and commercial practises in different low-tech industries. That is to say, forms of and conditions for innovations had only been one of several topics of the research. In principle the related work focuses on both pro??cess and product innovations though the main emphasis was on the latter. The differentiation used in the project is a rather pragmatic one. We conceptualised the development and launch of an item new to its producer as a product innovation and as process innovations those changes in the production process (in a wide sense including e.g. design and logistics) which representatives of an investigated company described as innovative.

This is admittedly very pragmatic. Roberto Simonetti and colleagues, for instance, introduced a far more elaborated conceptualisation in an article published a few years ago in *Scientometrics* (Simonetti et al. 1995). A bit simplified one may say that they establish the difference mainly with recourse to the location where an innovation has its first effects. When it is the producer, they argue, it ought to be taken as process innovation and if the first users are clients or another sector than the one where the novelty was created it is a product innovation (l.c.: 79-82). Their methodological argument is than that the character of an innovation can only be determined when you survey both sides. As this part of the case study research during the PILOT project focussed primarily on the conditions relevant for single low-tech producers we usually abstained from this.

About forty-five case studies in eleven European countries have been conducted. More than half of the firms belong to the metal working sector[4] the rest was distributed between selected other industries.[5] The selection of companies was not a representative sample and because innovation in low-tech has not been investigated very well so far, the case studies' purpose within the overall project was rather to state problems more precisely than to answer questions (see Schmierl & Kämpf 2004 for a general overview).

For the inquiry we used a standardised questionnaire to collect basic data on the respective company, its production process and its relations to suppliers, clients and, if so, partners. This research instrument was complemented by about half a dozen semi-structured extensive interviews for each case study (based on a master guideline common for all national project teams) with company representatives on different levels and with different functions, by site inspections and by an analysis of publicly available documents of the firms (catalogues, product specifications, internet presence, self-portrayals etc.).

In preparation of the part of the case studies discussed here we had to specify how to determine a mode of innovation specific for low-tech industries – if something like this can be established at all. Following the literature three criteria in particular came into consideration and have consequentially been taken up in the general interview guideline: (a) the degree of novelty of the products labelled innovative by managers or sales persons of the firms, (b) the causes and drivers of innovations (in the past, present and foreseeable future), and (c) the knowledge intensity of the "customary" innovation process or project.

(a) If one tries to determine the degree of novelty realised in an innovative product or process it is quite obvious to presume that innovation accomplished by a low-tech company is rather of incremental than of a radical character. The case studies confirm this hypothesis. But this is not particularly astonishing. If you

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4 NACE DJ.28: Manufacture of fabricated metal products, except machinery and equipment

5 Principally food, beverages & tobacco (NACE Subsection DA), textiles, apparels & leather (Subsections DB and DC), wood products (Subsection DD), paper, pulp products & printing (DE) or furniture (DN.36).

keep with the definition of radical vs. incremental as described above (page 2) innovations in low-tech surroundings are almost by definition of the incremental type. Hence, further differentiation was required.

(b) Characteristics specific to non-science-based innovations might be disclosed when one analyses the impulses or drivers of technical change. The case studies documented two main drivers of both product and process innovations: customer or market demand and regulatory incentives or requirements. In some cases R&D activities played a part but these were – again not really surprisingly – not described as a trigger for change. As a general rule they where only started to support a planned innovation project.

It is important to note that this finding does not justify a classification that describes innovation in low-tech as primarily market (and/or policy) driven and innovation in high-tech as primarily research driven. This would be far too superficial and merely reproduce the sterile dichotomy market-pull vs. technology-push.[6]

(c) A well known topic in the debate on innovation – and, for that matter, the knowledge society in general – is that the societal production process altogether becomes more and more knowledge intensive in the globally leading economies and that the relevance of knowledge intensive industries for these economies increases. This statement goes more often than not hand in hands with an understanding of high-tech sectors as being knowledge intensive and low-tech sectors as being not or less knowledge intensive; and this is taken to hold true for innovations in the respective sectors too.

That this is at least at first sight to some extend plausible is because it is usually only certain types of knowledge that are taken into consideration. As a matter of fact, in this narrow perspective codified and/or certified theoretical knowledge (usually grasped by summing up the expenditure for R&D, software and training) appears to be the main, if not only, source for innovations whereas experience and skills of workforce for instance in production tends to be neglected. But exactly the latter can be highly important for the speed and course of innovation in a firm. Therefore, the question of knowledge intensity was approached in the case studies by asking for content, sources and forms of knowledge inside and outside the firm which is relevant for its performance in innovation. Along these lines, we tried to reconstruct the investigated firms' knowledge base.

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6 It is empirically wrong anyway because with this argument one would purport that innovation activities in, say, the pharmaceutical industry are less market driven than in, say, the pulp and paper industry. It must be not very easy to substantiate this thesis.

In the course of the analysis of the case study results we sought to identify and explain patterns of innovations similar for a majority or all of the companies in the sample. In addition to those just sketched – they had already been taken up in the interview guidelines – other criteria that render a comparison possible were filtered out of the case study reports[7] namely (i) the frequency of innovations, (ii) the relevance of formal R&D, (iii) the nexus between product and process innovation, (iv) the degree of formalisation of innovation related activities, and finally (v) the degree to which knowledge relevant for innovation is distributed.

(i) *The frequency of – mainly product – innovations*

It was measured by comparing the number or share of products in a period that were classified as new or innovative by representatives (if possible sales people) of a company.

All but one of the respondents rated product innovation as very important for their respective business. This did not come as a surprise because we deliberately looked for firms who have a reputation as being innovative. Moreover, "innovation" is one of the powerful ideologies of the era. To be innovative is nearly a moral obligation at least for management these days. Hence, that the interviewees express high appreciation of innovation and of being innovative is what one could have expected. Notwithstanding, the case studies exhibit remarkable differences in terms of the actual occurrence of permanent product innovations.

The extremes have been on the one side two companies that manufacture to a large extent customised commodities and therefore every product may be more or less deemed a product innovation; one of them produces very large steel tubes, the other one railway points. In a way two of the furniture manufacturers in the sample are too quite close to this edge of the scale. But it is most evident that between the two pairs product innovation means something substantially different in terms of the effort needed to make a new product real. One part of the difference has to do with the fact that for the furniture companies the "standard innovation" is production of variations by reconfiguring existing parts which is impossible or at least not that easily possible for the steel processors. In several of the cases fashion matters for the firms' innovative behaviour but this does not necessarily mean cyclical appearance of new products.

At the other end of the scale we see a paper producer where you find hardly any product innovation at all though this company is very efficient in terms of

[7] What follows is meant to be the first step of a typology of non-science-based innovations which is being elaborated further during the PILOT project.

rationalisation, that is, process innovation. A Swedish manufacturer of armatures seems to be in a somewhat similar situation and two producers of metal products, one in Spain the other in Germany, too. Other enterprises are somewhere in between these two extreme positions.

In four of the cases companies diversified their product spectrum by offering innovative services directly related to their tangible products.

(ii) *The relevance of formal R&D – as defined in the Frascati Manual (OECD 2002) – for innovation projects*

This criterion is meant to grasp in each case the degree to which a company relies on project specific research and development work to be able to create a new product. That is to say, the criterion is not the importance of scientific or technological progress in general but the generation of firm-specific or product-related knowledge by scientific means as part of an innovation project. This comprises both internal and external R&D. The relevance was measured in terms of the estimated R&D expenditure for a project (intramural, collaborative or contract R&D).

Most of the companies in the sample conduct internal product development, some of them even applied research but only a minority maintain a formally established R&D department. Others utilise external research establishments. It is not only verified engineering knowledge and competence the analysed low-tech users need and are able to "absorb" but also, sometimes quite basic, new scientific knowledge (e.g. on material properties).

(iii) *The nexus between product and process innovation*

The question here was in how far product innovation and process innovation can be de-coupled. This is a way to approach the problem of firm specific techno-economic determination – or path dependency – of innovation. In principle, one extreme would be a company which has a wide scope of possibilities to realise new designs without being forced to give up established routines and/or to fundamentally reconfigure technical and organisational arrangements. In this case product and process innovations are loosely coupled. On the other pole, changing the product means inevitably procedural or technological changes.

There are at least three example in the sample where product innovation cannot meaningfully be separated from process innovation because the new product is a result of an innovative treatment of material. These examples the development of new product qualities by the processors of steel or other metals. Likewise clear is the relation in those cases where a modification in design or the application of new materials (new for the company) more or less directly necessitates changes in the production process, of machinery and/or of competencies. The producer of technical textiles, a printing house and a paper manufacturer allude to this type of nexus.

Things are less evident with two of the furniture companies. Here a product innovation does not necessarily have an impact on the processes within the gates of the innovating firms but poses mainly logistical problems along the value-added chain. The main task is here to concert the suppliers' activities.

(iv) *The degree to which innovation related activities are formalised*

Formalisation was determined in terms of the differentiation of departments and roles (researcher, development staff etc.) we found in a firm. Basically, the existence of functional departments such as R&D, Technology Department and Design Department etc. is one indicator for a rather high degree of formalisation. It was measured by the number of interfaces between organisational units involved in product innovation. A second indicator that was used to establish the degree of formalisation was the budgetary treatment of the activities (do they or don't they have an R&D budget etc.). A third indicator was whether (and if so, how) a firm embarks on a deliberate innovation strategy.

With regard to only a few of the companies in the sample can one really talk of a firm-wide planning of innovation. One case in point is the steel tube producer already mentioned above. In this enterprise the management tries to implement a strategic approach to product innovation throughout the firm (yearly declaration of a few projects with priority, appropriate target agreements with engineers and supervisors etc.). A producer of hinges for furniture implemented a formal three step innovation methodology which is supervised by a high-level management committee. In a way, the two fashion companies in the sample too have developed a certain *modus procedendi* to generating product ideas. On the other side we find for instance a meat fabricator and a paper producer where new product ideas are to a great extent an upshot of not very systematic trial-and-error processes or of individual intuition.

Dedicated departments (R&D, design, process engineering) – or single persons – responsible for innovation related activities exist in less than half of the cases. In some of the firms the development work is neither organisationally pooled in a unit nor centralised in one management position. Instead, it is conducted by staff members (mainly engineers and skilled workers) besides their regular job in production.[8]

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8 It may be presumed that this avoids or at least mitigates the notorious problems caused by the spatial, cognitive and social distance between developers in the lab and the manufacturing staff (and thus prevents ramp-up problems etc.). For quite obvious reasons this is a problem which low-tech and medium low-tech companies do not seem to face very often.

What all of the cases have in common is that the sales and marketing people are the single most important interface to customer demands and hence a prior source of suggestions concerning new or improved products.

(v) *The degree to which knowledge and competence relevant for innovation is distributed*

This item is due to the concept of "distributed knowledge bases" developed in Smith (2003a). Knowledge base means the "knowledge content of an industry" (l.c.: 14) or, when you focus on single companies, the knowledge a firm needs to endue to be able to be successful in its business. The classification "distributed" points out that this knowledge is not necessarily in possession of one organisation but can be spread out between various actors and different levels of accessibility.

When you focus on the sources of the relevant knowledge and expertise a distributed knowledge base can be described as a specific configuration of codified or tacit knowledge, actors and artefacts (that is, embodied knowledge).[9] The complexity of the respective configurations was determined by counting the links between the bearers of knowledge and expertise involved.

An interesting finding of the case studies was that for non of the criteria above the results were unambiguous. The most consistent was the picture with respect to this last point, the distributed character of the knowledge bases: with very few exceptions all of the investigated firms draw on a regular basis on external competence and knowledge. In other words, the knowledge they need to realise innovations is more or less dispersed.

Roughly, the sources of knowledge and expertise can be assorted into five groups of actors:

(1) Suppliers of equipment. This is a point for all of the companies. Though one of differing relevance. In some cases standard machinery is used, here one may talk of a transfer of embodied (or reified) knowledge. But in other cases the technology is either tailored or at least adapted to the companies needs. This inevitably implies mutual learning processes between supplier and client.

(2) Suppliers of components and material are in some of the cases another relevant source of knowledge. Namely in those firms where the producibility of a component is a limiting factor that a designer of the end-product has to take into account. Particularly illustrative are the cases where plastic or other injection moulded parts are used. Here again we can see interchange and reciprocal

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9 How knowledge flows within this configuration are organised is an empirical question, that is to say, the distributed actors do not necessarily constitute a network in the sense described e.g. by Powell 1990.

learning, this time between the end-producer on the one hand and the casting company and particularly the tool producer on the other.

(3) Most of the reports highlight that customers are not only an important trigger for product innovation but also a relevant source of related knowledge. This is particularly important for those of the firms that produce components for their customer's products (subsystems) because here the flow of and the ability to absorb highly specific knowledge about the needs and conditions of the context of application becomes indispensable for the supplier.

(4) Various kinds of consultants including trades associations as well as scientific advisors (test laboratories and research institutes). The terms of co-operation range from rather mundane supplier-buyer relations, for instance when a firm rewards a specified contract to an institute, to close collaboration of staff members with external experts.

(5) Finally we saw diverse service providers who's expertise is fundamentally relevant for the core business of many of the companies in the sample. Examples are designers and other creative partners or providers of non-scientific testing facilities.

In some cases we observed that technical methods or appliance (that is, embodied knowledge) developed for and well established in another context of application have been taken up by low-tech companies and adapted to their respective products and processes. In most of these cases this implied major technical (re-) design work.

3. Discussion

The results of this – preliminary – analysis support a suggestion also presented in a recent paper from SPRU on *Innovation in Low-Tech Industries*: "Knowledge search, identification and proof ... are likely to be of particular importance to innovation in the non-manufacturing activities of LMT [low-tech and medium low-tech] industries" (von Tunzelmann & Acha 2003: 4).

The capacity to search and find contributions that are potentially relevant for one's own core business and to integrate them into something new seems to be a central requirement for innovation in low-tech and medium low-tech surroundings. This resembles to what Rebecca Henderson and Kim Clark (1990) discussed as "architectural competence" – though with a very specific meaning. As already argued above, they link their concept very closely to a specific type of products, namely goods that consist of a multiplicity of components. What they call an architectural innovation is the reconfiguration of theses components that leaves their fundamental design untouched.

This is not necessarily the case when we look at innovations in low-tech and medium low-tech companies. Nevertheless, I would argue that Henderson and Clark's reasoning can be utilised for an analysis of innovation in these fields when you use the term architectural competence in a broader sense than the mothers of the concept did. Namely as the capability of an organisation to identify distributed, potentially relevant knowledge and adaptable technical solutions, to reframe them and to integrate them in novel ways and thus create new knowledge and new technical solutions.

The ability to integrate and synthesise different kinds of knowledge seems to be a feature which is of particular importance for innovation in low-tech firms, no matter whether they produce multi-component systems in the sense of Henderson and Clark or not. To avoid misunderstandings I suggest to characterise this as *synthesising competence* instead of architectural competence.[10] Henderson and Clark argued convincingly for their topic that such competence tends to crystallise as in routines, communication channels and filters and organisational structures (l.c.: 15-16) which is their way to explain path dependency. What they showed should also hold true for what is here called synthesising competence.

Helpful for an understanding of this interrelationship of factors is the concept "absorptive capacity" introduced by Wesley Cohen and Daniel Levinthal (1990). They argue that the ability to recognise relevant new knowledge and to incorporate it presupposes that there is already related knowledge and competence in the absorbing organisation. "We argue that the ability to evaluate and utilize outside knowledge is largely a function of the level of prior related knowledge ... [which] confers an ability to recognize the value of new information, assimilate it, and apply it to commercial ends. These abilities collectively constitute what we call a firm's 'absorptive capacity'." (Cohen & Levinthal 1990: 128)

It is well known that for Cohen and Levithal research is the major mode to stimulate learning processes which finally lead to the development of absorptive capacity. But there is, in principle, no reason why their main argument should not also hold true for processes of accumulation and generation of knowledge such as learning by doing, by using or by integration which are in general more typical for low-tech and medium low-tech firms (cf. also Palmberg 2002). To determine more precisely how absorptive capacity is being built up in these

10 In earlier drafts of this paper I referred to this type of ability as "integration competence". I am indebted to Hartmut Neuendorff for his suggestion of the term synthesising which illuminates much better that it is about *generating new* knowledge and novel products.

companies (or more general: industries) and how its creation can be facilitated is obviously not only of scientific interest but also a highly relevant topic for efficient innovation policy.

4. Conclusion

The recourse to both Henderson & Clark and Cohen & Levinthal marks off cornerstones of a twofold concept – a focus on synthesising competence and the preconditions to develop it (absorptive capacity) – which can be used to analyse (problems of) non-science-based innovation processes. And presumably not only for this. A lot speaks in favour of the assumption that as for the relevance of synthesising competence for innovation there is no difference in principle between high-tech (i.e. research intensive) and low-tech surroundings but that variations lie merely in the specific shape of the emerging configurations preponderant in each case, that is to say, the spread and kind of inter-linked knowledge and actors. Following this proposition I would like to conclude with four theses.

Firstly: Innovation is based to a large extent on the synthesising competence of actors, that is, on their ability to tap distributed competence and knowledge, to reframe them, and to recombine them creatively. This may be scientific knowledge, design competence, or expertise in logistics, it may be codified knowledge or knowledge which is incorporated in humans or in technical artefacts. That is to say, scientific research and knowledge is only one source of innovation.

Secondly: A promising strategy to enhance the innovative capacity of a region or nation is to support the capacity in particular of not research intensive companies to not only use distributed knowledge bases but to habitually reconfigure them over and over again. It is very likely that this is at least as important as to foster high technology.

Thirdly: Innovation is not only a process of creative destruction but frequently one of a recombination of knowledge, artefacts and actors. A conceptualisation that highlights that innovation is not merely something scientific or technical with economic consequences but implies changes of actor configurations and social relations helps to grasp this point.[11]

Fourthly: The thesis that the developed societies of the Triad are high-tech based is wrong – if this is meant to say that everything of import is linked to the

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[11] This is at least potentially far more than a matter of supply chain management. “Innovation is a social process that entails a change in a network of social relations. Innovation is thus about changes in some or all of an existing set of identities, expectations, beliefs and language.” (Woolgar 1998: 444)

creation of high-technology and new scientific knowledge. A non-receptive environment weakens also the providers of research based goods and services (cf. Robertson et al. 2003) and thus the efficiency of the whole system. Hence, a conception which focuses primarily on the supply side is inadequate.

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