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The organisational decomposition of innovation and territorial knowledge dynamics – insights from the German software industry

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Abstract:

In recent years, innovation processes involve more heterogeneous actors inside and outside the firm. Little is known however about the spatial impact of this organisational decomposition of innovation processes (ODIP): Does it lead to a geographical dispersion of innovation activities as well? Furthermore, which parts of the innovation process are carried out spatially or organisationally separated? To what extent are knowledge-creating activities subject to organisational decomposition? We propose the analytical ODIP framework which integrates research on innovation systems, global value chains and knowledge-intensive business services (KIBS). Thereby we provide a conceptual contribution to the debate on the globalisation of innovation in the identification of different modes of decomposed innovation processes by capturing the participating actors and their contribution in specific innovation events. The exploration of the spatial dimension of innovation processes in the software industry shows that the global-local dichotomy in the innovation debate does not suffice to describe their complex, multi-scalar nature. In analysing ODIP in a knowledge-intensive industry, we contribute to the debate about the 'new geography of innovation' by providing insights into the upgrading of subsidiary capabilities.

Keywords: ODIP, innovation, software, territorial knowledge dynamics.

JEL Classifications: D83, F23, L14, L86, O32

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1. Introduction

Particularly in OECD countries changes in the organisation of innovation became obvious in the mid 1990s. Indicators are the internationalisation of business R&D which in itself is not a new phenomenon, but seems to take place in a much faster pace and is spreading more widely. A major change in the spatial distribution of innovation, often discussed as the new dimension of globalisation, is the integration of non-OECD countries including developing countries such as India and China in R&D networks of multinational corporations to much larger extents (OECD 2008, UNCTAD 2005). A shift to more open innovation environments and the growing importance of external knowledge in innovation processes is stated in different strands of innovation research. MNCs are important actors shaping knowledge dynamics across spatial and cultural borders and contributing heavily to the internationalisation of innovation along their global value chains. However, we do not focus on them exclusively, but put the organisational decomposition of innovation (ODIP) and its spatial implications at the centre of our paper: How does the organisational decomposition of innovation in OECD countries influence territorial knowledge dynamics?¹

The debate on this question is quite controversial. On the one side there seems to be a consensus in the literature that the major share of MNCs' R&D in India and China comprises routine activities geared to adapt existing designs or to provide more standard parts in innovation processes transformed and integrated in innovative products and processes by firms in OECD countries (Bruche 2009). On the other side scholars active in global value chains and subsidiary research point to fast learning processes and the build-up of innovation capabilities of firms in non-OECD countries. These authors make out a far-ranging transition and assess the scattered empirical evidence as an indication of China's and India's change from production to innovation (cf. Altenburg/Schmitz/Stamm 2008, Lema 2010, Quadros 2009). It is argued that these countries are taking advantage of new opportunities to organise global value chains by investing strategically in their national innovation systems and stepping up their innovation efforts to constantly renew their competitive advantages. The catching up of several industries as well as an increase in innovation capabilities of firms combined with the increasing offshoring of knowledge-intensive services is considered as an indication for a new global dynamic and a shift of innovation activities.

While the rise of a new geography of innovation is discussed, the assessment of territorial knowledge dynamics which unfold and go along with distributed innovation processes is still an open question. Obviously the offshoring of business R&D and knowledge-intensive service activities to low cost countries indicate a higher degree of complexity in the international division of labour. As the organisational decomposition in the sphere of production is an

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ongoing process, ODIP is not a static phenomenon either. Some forms of ODIP might exist since years, but others emerged not until recently, leading to an increase in diversity. Yet relatively few insights are available regarding the linkages and impacts of organisationally and geographically dispersed innovation processes as well as differences and commonalities between sectors.

Our paper seeks to provide deeper insights in modes of organisationally decomposed innovation processes by arguing that it is necessary to open up the black-box of knowledge interactions and take into account the mutual reinforcement of linkages between actors, knowledge interactions and their territorial embeddedness. We will explore ODIP in the German software industry and its territorial organisation.

The following **section 2** provides the analytical framework which helps us to explore different types of ODIP. Drawing on several approaches such as systems of innovation, global value chains and research on knowledge intensive business services (KIBS), we show that the organisational decomposition of innovation processes can occur in different ways. **Section 3** elaborates on the sector specific organisation of innovation processes in the software industry. The empirical analysis of ODIP in the software industry starts in **section 4** which also contains the methodological issues. The empirical results of the case studies are presented in **section 5**. We analyse the occurrence of ODIP, the practiced modes and the types of actors involved in these processes. One major outcome of the study in Germany is that the strongly pronounced global/ local dichotomy in the innovation debate falls short of the complexity and spatial differentiation of innovation processes. Especially the multi-local and multi-scalar character of organisationally decomposed innovation processes is significant in the software sector. In **section 6** we put the micro level results into the broader macro level perspective by coming back to the initial question whether the organisational decomposition of innovation processes in OECD countries influences territorial knowledge dynamics. On the basis of our results we reflect the debate on a qualitative shift or a changing geography of innovation.

2. The organisational decomposition of innovation – actors, processes and the territorial dimension

Innovations in products, processes and services are the visible results of interactions between heterogeneous actors from inside and outside the firm embedded in spatially distributed networks. To gain insights on actors, processes and the territorial dimensions of innovation processes, we have proposed the analytical framework of “ODIP” (Schmitz/Strambach 2009). Its aim is to capture the decomposition of innovation, compare these processes between sectors and to understand dynamics in the spatial organisation shaped by these processes.

The literature strands on systems of innovation, MNCs, Global Value Chains (GVC) and KIBS (knowledge intensive business services) show that organisational decomposition can occur in different ways and can involve a variety of different types of actors (cf. Schmitz/Strambach 2009). Research on innovation systems emphasizes the importance of tight linkages between

firms and research institutes or universities for the generation of knowledge in innovation processes (Cooke 2001, Asheim/Gertler 2005). Furthermore, subsidiaries who have been primarily concerned with the production of goods and services, increasingly play a prominent role in intra-organisational innovation networks (Frost et al. 2002, Zander 2002, Zanfei 2000). Research on GVCs and Global Production Networks (GPN) point out that external suppliers are often expected to generate the knowledge that is required to produce improved or new components or systems. (Jürgens 2000; 2001; Humphrey 2003). Additionally, the literature strand on KIBS outlines that KIBS have important roles as carriers and traders of knowledge and foster knowledge dynamics at multi-levels.

Drawing on these insights we define ODIP as the process by which firms shift parts of their innovation processes from their headquarters and centralised R&D department to decentralised R&D departments, subsidiaries, public/private research organisations and suppliers or KIBS.

The added value of the ODIP framework is the conjunction of these three different strands. Similar to the approach to “systems of innovation”, all actors, which play an important role in the innovation processes, are analysed. Not just the actors directly included into the GVCs of MNCs are analysed, but also the regional context and the relationships between local actors like universities, research institutes, customers and KIBS are seen as important parts of global innovation processes. However, to capture the geographic dispersal of innovation processes, we do not a priori conceive territories as a fixed geographical sphere bounded by the borders of a certain “innovation system”, but aim to cover the entire territorial scope of a firm’s distributed innovation processes.

The ODIP framework consists of four actor types and four ODIP modes. Thereby, *actor types* are assigned to the actors participating in innovation processes with regard to their belonging to organisational and functional dimensions (table 1). The organisational dimension relates to whether or not the participating actor is within the case study firm (intra-organisational) or external to the sample firm. The functional dimension refers to the business function an actor holds. Innovation can be delegated to those who are primarily concerned with knowledge creation and have only a loose connection with the production of goods and services or to actors who are primarily active in knowledge-using activities, which are tightly connected to the production of goods and services.

Tab. 1: Actor types according to the ODIP framework

Organisational Functional	Intra-organisational	Inter-organisational
Knowledge Creating (exploration)	Actor Type 1 Decentralizing the R&D Department; Setting up Knowledge Communities	Actor Type 3 Commissioning research from universities or other organizations
Knowledge Using (exploitation)	Actor Type 2 Delegating the development of new products to subsidiaries; Setting up Centers of Excellence	Actor Type 4 Engaging suppliers of products and services (KIBS) in developing new products or processes.

Source: Adapted from Schmitz/Strambach 2009.

The constellation of different actor types involved in an organisationally decomposed innovation process distinguishes the *ODIP mode* a firm follows. These four ODIP modes stand for four different settings in organisationally decomposed innovation processes. By ODIP modes, we understand relatively stable patterns of diverse actor types and their networks in knowledge interactions. Decomposed innovation processes imply a labour division in knowledge production. While innovation research in particular is focussed on the importance of knowledge sources in innovation processes, like customers, suppliers, cooperation partners or research organisations, little is known about the complex constellations of such actors and their labour division in knowledge interactions.

Tab. 2: Modes of ODIP

Characteristics ODIP Modes	Organizational Dimension: intra-/interorganisational	Functional Dimension: Knowledge creating / using	Spatial Dimension: same/different scale
ODIP Mode I	Actors from one organizational dimension	Actors from one functional dimension	regional/national/international
ODIP Mode II	Actors from both organizational dimensions	Actors from one functional dimension	regional/national/international
ODIP Mode III	Actors from one organizational dimension	Actors from both functional dimensions	regional/national/international
ODIP Mode IV	Actors from both organizational dimensions	Actors from both functional dimensions	regional/national/international

The distinction of the four modes of ODIP is based on the suggestion that these differ in their level of complexity, influenced by the organisational and functional boundaries which have to be bridged, by the scope of external relationships which have to be managed and by the diversity of actors with distinct knowledge bases which collaborate. The diversity of actors with heterogeneous knowledge bases and the level of common knowledge influence heavily the scope of knowledge being integrated in distributed innovation processes (Grant 1996). Thus, an empirical case is related to the most complex mode of ODIP, mode IV, if actors from intra- and interorganisational dimensions and knowledge-creating as well as knowledge-using actors are part of the innovation process.

This case appears complex because the organisational and cognitive proximity of involved actors is low. Organisational proximity may be regarded as a form of common knowledge between actors created by informal and formal routines which facilitate knowledge integration. Referring to the conventional tension between production and R&D, cognitive distance between actors being professionally engaged in similar functional fields may be smaller. In turn cognitive proximity facilitates communication, mutual understanding and knowledge integration (cf. Nooteboom et al. 2007, Boschma 2005).

We are using this developed framework of ODIP to examine and compare the different empirical forms of decomposed innovation processes and their territorial shaping. It is widely acknowledged that innovation processes have significant sector- and industry-specific characteristics. Hence, we will in the following present some sector-specificities which may influence the way innovation is decomposed in the software industry.

3. Innovation and production in the software industry

It is meanwhile widely acknowledged in the interdisciplinary field of innovation research that innovation processes have significant sector- and industry-specific features (for example Pavitt 1984, Malerba 2002/2005). Compared to many mature industrial and manufacturing industries, the evolution of the software industry to an autonomous sector is a relatively recent development. From a technological point of view, software can be seen as a cross sectoral technology. From a sectoral point of view, it is a knowledge-intensive service industry. Insights into innovation of the software industry are still scarce amongst others due to fact that there is no sharp line between production and innovation in the software industry. While in manufacturing industries the production and innovation systems are organisationally differentiated and innovation processes imply a deviation from the usual operational working procedure, in KIBS industries like the software industry both are closely interwoven. Innovation is not a separate activity; it takes place mostly in an ad hoc manner in the client interaction processes and in the production of customer specific problem solutions (Djellal et al. 2003, Hipp/Grupp 2005, Mueller/Doloreux 2007, Strambach 2008). The internal processes of knowledge creation are only weakly formalised, as has been shown by empirical research (Hauknes 2000, Sundbo 2000, Marklund 2000). In contrast to manufacturing firms, most KIBS firms do not distinguish R&D activities systematically in organisational terms as R&D departments or R&D management structures. Knowledge exploration and exploitation often overlap and take place simultaneously (cf. Friedewald et al 2002, Holl et al. 2006, Segelod/Jordan 2004).

Project-based work is the dominant form of work organisation in software development to produce client specific problem solutions. Innovation is inherently defined by novelty, but in these knowledge intensive industries every project implies a certain degree of uniqueness, thus is in a sense new. Due to the customer-specific context in which knowledge is applied, the individual task varies significantly. In the software industry innovation measures have to be geared to uncover routine problem solving from innovative problem solving. Traditional innovation statistics, input as well as throughput measures like patents, are often not appropriate in achieving this. Miles/Green (2008) for instance point out that many innovation activities of knowledge intensive service industries as the software industry are likely to remain hidden from innovation researchers.

Distinct characteristics of innovation in the software industry are short innovation cycles and a high dynamic. As a considerable body of literature shows, the software industry increasingly relies on external knowledge sources, especially inter-firm linkages (cf. Grimaldi/Torrisi 2001, Segelod/Jordan 2004, Friedewald et. al 2002, Tödting et. al. 2006). Yet there is a broad variation regarding the importance of different types of knowledge sources and their spatial dimension. Even though there is no clear cut outcome of the complex architecture of different types of actors' linkages in innovation processes, a common finding of all studies is the importance of the relationships to customers in all phases of the software development. Clients seem to be the main trigger for knowledge creation. Feedback from customers becomes important not only in the idea phase but also in the design, development, and

commercialisation phases to align the end product to customer needs and demands as these are made increasingly explicit (Segelod/Jordan 2004). Particularly in the software sector the knowledge domains in which the firms operate are shaping both the development of the specific knowledge base of the firms itself and the expertise of their professionals in a co-evolutionary way (cf. Løwendahl 2001:914).

Recent research with a macro level perspective indicate that institutions are potentially important, given that evolution of the software sector very much depends on complex, often long-term relationships with client firms in other sectors of the economy (cf. Grimshaw/Miozzo, 2006). As shown on the development of the German software industry, the interplay between the institutional context of the national innovation system and the pattern of demand over time contributes to the specialisation and competencies of this industry (Strambach 2010). The social embeddedness of economic transactions is crucial in the dynamic production of knowledge-intensive services (Tödtling et. al. 2006). Furthermore the software industry seems to be an example for the implementation of industrial methods such as standardization and modularization into service production. The outsourcing and offshoring processes gain more importance in the software industry, raising the question if we can observe a vertical disintegration in knowledge-intensive activities comparable with the organisational decomposition of production in manufacturing industries.

4. Methodology

The access to information which clarifies and explains the organisation of innovation processes in software companies required a number of case studies. They were achieved by semi-structured interviews with actors playing a significant role in innovation processes of firms in the software industry. We selected a number of software-producing subsidiaries of MNCs in the software and automotive industry (Baden-Württemberg as region of origin of MNCs and with foreign subsidiaries in India preferably).

The development of each case study was accompanied by intense desktop research including publicly available data on R&D-facilities and –organisation and on important innovation-oriented collaborations. Then in-depth interviews with senior managers in charge of the innovation management and/or innovation project managers were undertaken.

Thirteen case studies, all comprising software firms having their headquarters or significant development units in Baden-Wuerttemberg, were conducted. The firms were active in the development of internet business portals, business software, database solutions and embedded software. Basically, we analysed specific innovation events to capture the actors and their activities in ODIP. Yet, since each innovation event may feature different actors constellations, additionally firms have been analysed to capture changes in their general innovation process management and territorial organisation. The Indian subsidiaries are represented by three case studies based on in-depth desktop research and interviews in Bangalore (India) and Germany. Furthermore, interviews with three regional support organisations in Baden-Wuerttemberg and India aiming at networking and technology transfer, contributed to the examination of ODIP in software firms from Baden-Wuerttemberg. In the

following empirical analysis, all firms are anonymized unless information is publicly available through articles, papers, websites, databases, etc. The abbreviations indicate the products of the firms: While NET stands for firms active developing internet portals or web services, BS stands for business software firms, providing solutions for finance services (BS_FIN), outsourcing (BS_OUT), databases (BS_DAT), customer relation management (BS_CRM), automobile manufacturing (BS_AUTO) and business simulations for e-learning (BS_SIM).

5. Empirical results

5.1 Actors and Processes in ODIP of the software industry

As mentioned in section 2, in the ODIP framework actors are typified according to their organisational characteristics. On the one hand, the organisational decomposition of innovation can take place within or between organisation(s), on the other hand it may involve actors active in the creation or the using of knowledge. This typology allows the determination of the organisational and functional borders which have to be crossed within an innovation process, providing important information about the different forms of distance and proximity the innovating firm has to take into account. The table below reflects the occurrence of actor types in the analysed case studies.

Tab. 3: Overview of the case studies – Actors in organisationally decomposed innovation processes

Actor Type	Case study	NET1	NET2	BS_DAT1	BS_FIN1	BS_OUT	BS_DAT2	BS_CRM	BS_AUTO	BS_SIM	BS_FIN2
		Actors									
4	Customer	X	X	X	X	X	X	X	X	X	X
	Suppliers/Private KIBS						X		X		
3	Public KIBS						X			X	X
2	Subsidiaries					X		X	X	X	X
1	Decentralized R&D										X

Source: Own research

Furthermore, we have analysed the software-producing subsidiaries located in India of three large MNCs active in embedded software (AUTO_IT), telecommunication solutions (COMM_IT) and business software (BS_GLOB). They are not included in the table above, since they have not been analysed by the depiction of a specific innovation event (see section 4).

It shall not surprise that customers play a role in every case, since customers are important as co-creators and co-producers of knowledge-based solutions (Bettencourt *et al.* 2002, Gallouj 2002, Grimshaw/Miozzo 2006, Mueller/Doloreux 2007, Strambach 2008). Furthermore, organisationally decomposed innovation processes are characterized by little presence of suppliers, public KIBS and R&D departments. However we could find that several software firms involve knowledge-using subsidiaries in their innovation processes.

Modes of ODIP

As it can be seen, software firms do not follow one single mode of ODIP. While there are some firms who engage all types of actors in their innovation processes, there are also firms who show very few linkages to external actors. In the following we introduce our typology of modes of ODIP which are differentiated by actor constellations. (cf. section 2).

Three groups of firms could be identified following the distinct ODIP modes above: **“Customised solution providers”**, referring to mode I, **“cost-driven outsourcing firms”**, relating to modes II and III and **“innovation process managers”**, which practice ODIP mode IV. We merged firms who practice ODIP mode II and III into one group, since we cannot find distinct differences in their patterns of knowledge interactions.

Tab. 4: Modes of ODIP, differentiated by actor constellations

Characteristics Modes of ODIP	Organisational Dimension: intra- /interorganisational	Functional Dimension: Knowledge creating / using	Spatial Dimension	Firms	Group
ODIP mode I	Actors from one organisational dimension	Actors from one functional dimension	regional/national/ international	NET1, NET2, BS_DAT1, BS_FIN1	Customized Solution Providers
ODIP mode II	Actors from both organisational dimensions	Actors from one functional dimension	regional/national/ international	BS_OUT, BS_CRM, BS_AUTO	Cost-driven Outsourcing Firms
ODIP mode III	Actors from one organisational dimension	Actors from both functional dimensions	regional/national/ international	BS_DAT2	
ODIP mode IV	Actors from both organisational dimensions	Actors from both functional dimensions	regional/national/ international	BS_SIM, BS_FIN2, BS_GLOB	Innovation Process Managers

“Customised solution providers” are firms (e.g. NET1, NET2, BS_DAT1, BS_FIN1), whose sole external contribution to the innovation process results from intense interaction between the software firm and the customer. Their relation to public knowledge creating organisations is limited to the sourcing of highly-skilled personnel. Another feature is that they do not possess subsidiaries involved in innovation processes. In the KIBS literature, these firms and their behavior have been thoroughly investigated. The second group of firms (BS_OUT, BS_CRM, BS_AUTO, BS, DAT2), which will be called **“cost-driven outsourcing firms”**, has established subsidiaries who are also involved in innovation processes and source knowledge from research institutes and universities, so called public KIBS as well as private KIBS or suppliers. This means an increase of complexity for the management of innovation processes in comparison to firms of group 1, as the scope of knowledge integration is higher. Nevertheless, the firms’ knowledge creation efforts are rather aiming at the absorption of new technologies (out of external sources like publications or incorporated in human resources from universities

and colleges). Yet, to whatever extent new knowledge is created; it is not represented by a decentralization of the firm's R&D efforts in form of a formal organisational unit. The third group in our typology is formed by "**innovation process managers**" (BS_SIM, BS_FIN2, BS_GLOB), who decentralize their R&D activities. Their subsidiaries do not only carry out knowledge-using tasks during the innovation process, but contribute to the knowledge-creating efforts of the firm. Furthermore, the complexity of knowledge interactions in their innovation processes is very high, involving several intra- and interorganisational actors with specialised knowledge bases, spread over several functions. Their innovation process design is characterized by the inclusion of a flexible mix of internal and external actors at different stages of the innovation process, thereby complementing knowledge using functions with systematic knowledge creation within intra- and interorganisational settings.

Labour Division in Knowledge Production along the value chain

Following the identification of actors involved in distributed innovation processes, a further insight into the processes and tasks assigned by the innovating firm to various actors is necessary to clarify at which stage of the value chains software firms delegate parts of their innovation processes to internal or external actors. Through the investigation of value chains we could also gain insights into the activities which are subject to organisational decomposition.

The "**customised solution providers**" of group 1 not only show a low level of decomposition of innovation processes onto external actors, but their internal innovation processes can also hardly be represented as value chains. Basically they cannot be termed as 'multinational companies', but we have included them in our analysis nevertheless. The differences between software MNCs and these firms may indicate the factors limiting the international decomposition of innovation processes in the software industry.

In firms of group 1, knowledge using and knowledge creating activities are closely interwoven. A common practice of these firms is to carry out knowledge processing in interdisciplinary project teams composed of both client staff and their own. Rather, as typical for KIBS industries (Strambach 2008, Gallouj 2002, Mueller/Doloreux 2007) the nature of their innovations can be characterized as "ad-hoc innovation": They are un-planned by-products of innovative projects the firm carries out in frequent interaction with their customers, taking place at all stages of the product development. Hence, even though the firms' products might be highly innovative, they do not maintain R&D departments. They even may not have formalized any organisational routines for the management of innovations. Their "innovation management" can often be described as the fostering of ideas and their communication in a working atmosphere, which one interview partner entitled "coffee table culture" ("Kaffeetischkultur").

The weakly formalized knowledge creation process and the lack of organisational routines such as a formalized innovation management (also see Friedewald et al 2002) - does not necessarily reflect a low degree of innovativeness. It points to re-contextualisation as an important mechanism of knowledge creation in the software sector. Re-contextualisation can be

understood as the process of direct contextualisation of individual or collective tacit knowledge without it being transformed through codification (Strambach 2008). Codification processes themselves are context-dependent (Cohendet/Meyer-Krahmer 2001) and the discontinuous and temporary nature of innovative projects acts as a significant brake on knowledge codification. These software firms act in highly volatile knowledge markets and the systematic knowledge generated as an activity 'far' from the customer context may turn out to be economically useless after a relatively short time-span.

In *group 2* however, there are "**cost-driven outsourcing**" software firms who have defined value chains and are able to involve several actors in their innovation processes. Their most prominent feature is the establishment of a subsidiary – mostly in a developing country - which executes certain parts of the value chain to reduce costs and raise flexibility. The typical model of ODIP in *Group 2* is characterised by a close interaction between the innovating firm and its customer in the initial and final phases of an innovation event, visualized in Fig. 1 below. The initial phase, in which the problem framing takes place, is crucial for the design of software architecture: misunderstandings in this phase can cause the whole project to fail. Even in this early stage these software firms activated external actors (e.g. research institutes, consultants, software component suppliers) to integrate highly specialised knowledge bases for the specification of the required knowledge architecture to develop the complex problem solution. Offshore subsidiaries are usually involved in a later stage mostly in the middle of the innovation process.

According to our research and the existing literature, a product development model can be identified for the "cost-driven outsourcing firms" (see Fig. 1). It shows the different activities and their characterization as high or low level design based on the increasing share of knowledge creation activities compared with ones of knowledge using. The tasks assigned to offshore subsidiaries of the case study software firms in group 2 comprise mainly the coding and testing of software, which are easy to specify and communicate and hence spatially transferable. However, subsidiaries are hardly involved in the final, direct customer interaction, in which the product is implemented in the complex customer context and its existing software environment. Hence, our results show, similar to those of other authors - that in distributed innovation processes activities with a high level of knowledge creating activities remain to be conducted in Germany. Decomposition of such activities involves high efforts in knowledge integration, coordination and governance due to the process character of knowledge and the uncertainty with regard to the quality and the appropriateness of the knowledge product. Subject to delegation to actors in non-OECD countries are mainly those parts in the innovation process characterized by a high degree of knowledge using activities. However, we could note that in some cases, due to learning processes over time the tasks assigned to offshore subsidiaries are extended towards activities comprising a higher level of knowledge creation such as design and analysis/requirements.

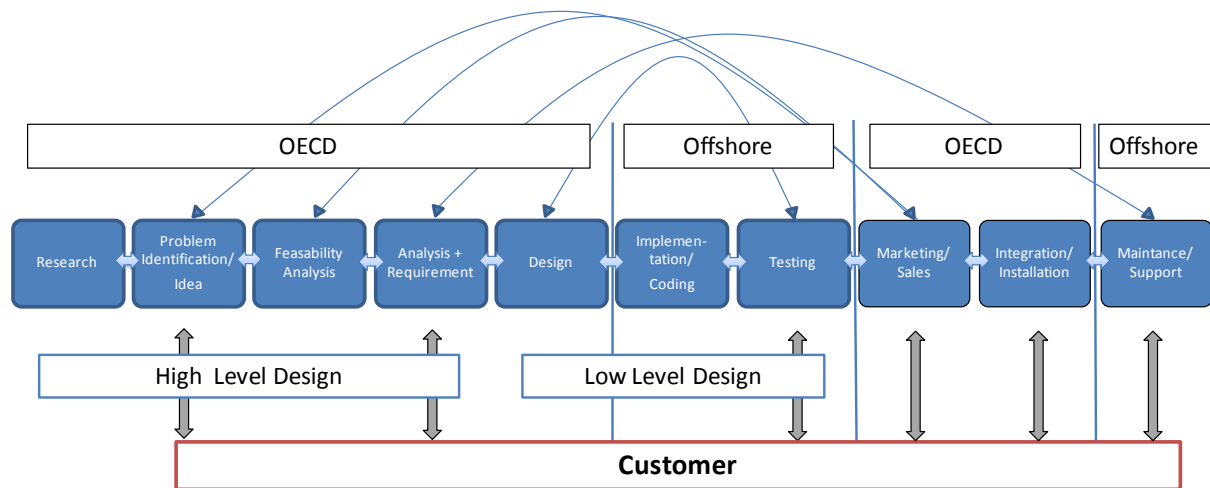


Fig. 1: Product development process of “cost-driven outsourcing firms”

Source: own figure, based on Segelod and Jordan 2002; Royce 1970;

In the following, the innovation event “ePep” of the firm BS_AUTO will be presented in order to give an example for the practice of ODIP mode II along the typical product development process.

Here, the innovation was the highly sophisticated software “ePEP” which supports all stages of the production process of the customer, the Trucks Europe/Latin America department of a German automaker. The entire engineering and manufacturing process at different sites had to be streamlined by the new software solution, replacing more than ten heterogeneous legacy systems. The development of this software was conducted by BS_AUTO, located in Ulm, Baden-Württemberg, which delegated parts of the software development to its subsidiary BS_AUTO Malaysia in Kuala Lumpur. BS_AUTO decided to achieve a higher degree of capacity utilization of its offshore resources to increase its profitability. Hence, they purchased a software solution of business software provider BS_OUT2, located in Freiburg, Baden-Württemberg, which facilitates offshore working models through the standardization and specification of software components. Furthermore, this firm acted as a consultant for the customization and application of the product.

As shown in the value chain visualisation below in figure 2, in an initial phase of the project, the architectural design was accomplished in close interaction between the customer, the German headquarter of BS_AUTO and BS_OUT2. The latter’s role was to kick-start the process, support architecture development, train employees and consult BS_AUTO in the transformation of the legacy systems. The use of BS_OUT2’s software enabled BS_AUTO to outsource the component design to its Malaysian subsidiary at a relatively early stage of the innovation process. Thus, the subsidiary’s tasks have been extended upstream the value chain. After a verification of the components developed in Malaysia by the HQ of BS_AUTO and the customer, the Malaysian subsidiary of BS_AUTO implemented the components and tested them. The originally existing different skill levels remained intact to a certain extent. In the last steps of the innovation process BS_AUTO Germany interacted closely with the customer and the software supplier BS_OUT2 during the verification, integration and final testing of the developed software.

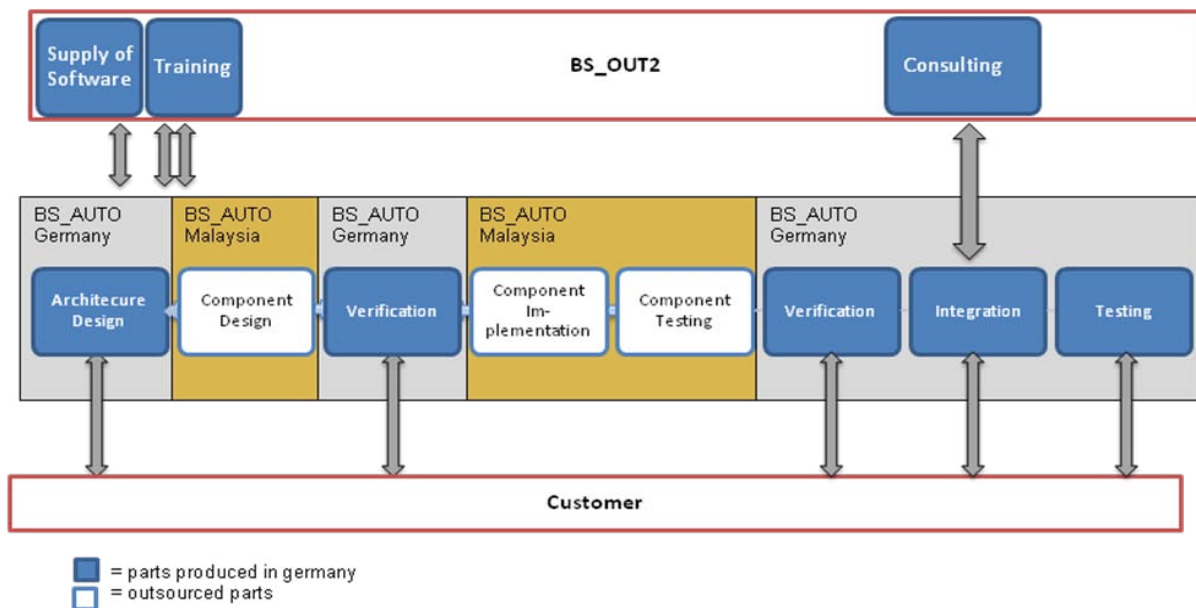


Fig. 2: Modularised software development process at BS_AUTO

The case of BS_AUTO shows how technological solutions can support the decomposition of innovation processes, thereby upgrading the quality of tasks assigned to a software firm’s subsidiary upstream the value chain. Nevertheless, the subsidiaries of these “cost-driven outsourcing” firms are assigned to knowledge-using tasks for the most parts. This group of software firms shows that the development of organisational routines to dissolve the close connection between knowledge exploitation and knowledge exploration is a precondition to decompose innovation.

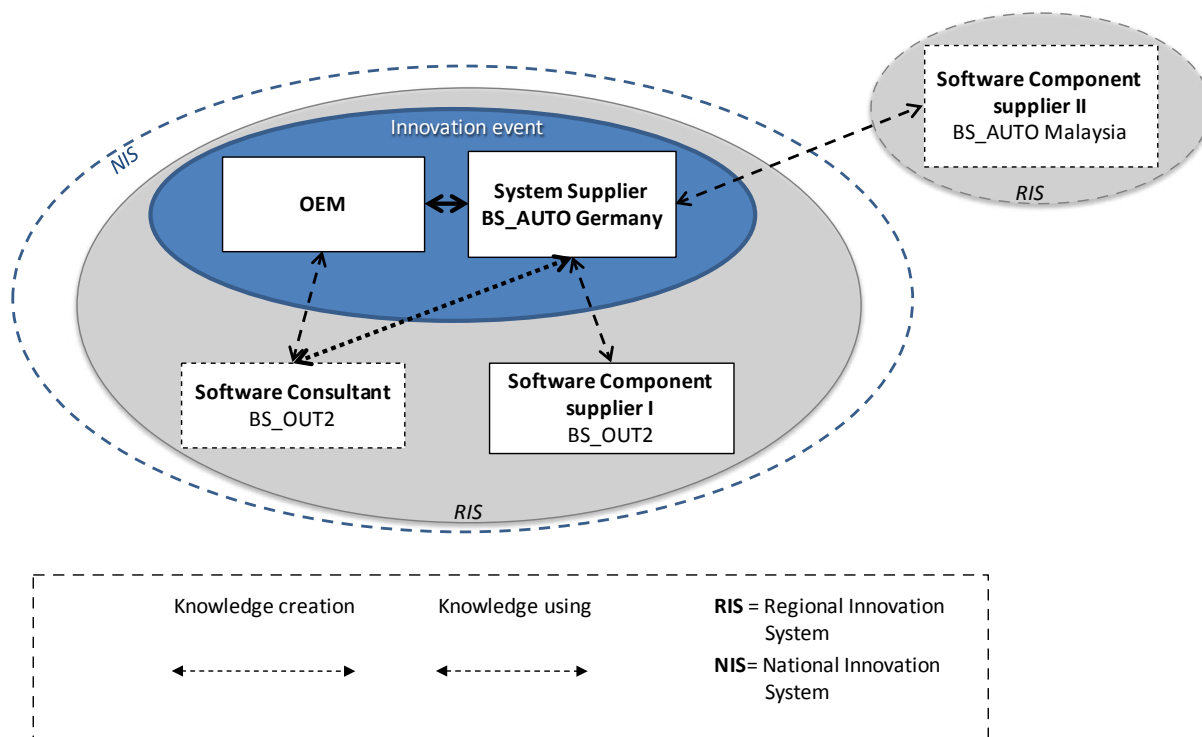


Fig.3: Spatial dimension of the innovation event of BS_AUTO

The *third group of* software firms cover the **innovation process managers**, which practice ODIP mode IV and are organisationally very close to MNCs of manufacturing industries. Their value chains are determined and their innovation management is strongly institutionalized. There are several formalized organisational routines established to coordinate knowledge production within the firm and even for the joint cooperation with customers.

What distinguishes these firms from the other cases is particularly the role which their subsidiaries play in decomposed innovation processes. Their subsidiaries show a high degree of autonomy by carrying out own knowledge creation activities and possessing independent relationships to customers. They have established networks to different actor types in their local context which support them in knowledge creation processes. Thus, the main organisational capability of ‘*innovation process managers*’ is to utilize the accumulated knowledge base of its subsidiaries in innovation processes. For example BS_FIN2 has established a separate organisational unit, the so called ‘technology office’ which is responsible for the de-contextualisation of generic knowledge parts out the locally accumulated context-specific knowledge of its subsidiaries to make it available for the use in innovation projects in distant places.

5.2 The territorial shaping of ODIP

Since we have approached the spatial dimension in an indirect way so far, in this section we address the territorial shaping of ODIP more directly. Firstly by examining the location of actor types participating in decomposed innovation processes. Secondly, we will focus on foreign-based subsidiaries to explore their changing role in ODIP over time. The importance of territoriality in knowledge processes is discussed mainly under two dimensions - proximity and embeddedness. With the following analysis we seek to gain insights how these dimensions are related to ODIP.

Tab. 6: Overview of the spatial distribution of actors in ODIP

Actor Type	Case Study	Customized solution providers				Cost-driven outsourcing firms				Innovation process managers	
		NET1	NET2	BS_DAT1	BS_FIN1	BS_OUT	BS_DAT2	BS_CRM	BS_AUTO	BS_SIM	BS_FIN2
4	Customer	NIS	NIS	NIS	South Africa	NIS	RIS	RIS	RIS	NIS	NIS
	Suppliers/Private KIBS						RIS		RIS		
3	Public KIBS						RIS			RIS	RIS
2	Subsidiaries					India, Sweden		Egypt	Malaysia	India	Hungary, Spain, Brazil
1	Decentralized R&D										India

Notes: RIS = Regional Innovation System, NIS = National Innovation System

Independent of the kind of innovation and the practiced mode of ODIP the empirical findings indicate that particular types of actors are found on the same spatial scale. While the relations to customers, public and private KIBS are mainly regionally and nationally located, the linkages to subsidiaries and R&D centers cross national borders. The linkages to customers, public and private KIBS imply a high level of knowledge-creating activities, such as problem-framing or

collaboration in research activities. To achieve the integration of diverse and specialized knowledge bases of these actors a certain degree of spatial proximity appears to be required. By overcoming cognitive distance, intensive and rich communication processes are present to build a level of common knowledge and to establish a mutual understanding on the needed 'knowledge architecture' as well as to articulate procedures for knowledge exchange during the creation process. Co-presence, frequent face-to-face interactions and the necessity of temporary geographical proximity amongst the actors do play an important role. It is particularly the flexibility of spontaneous and situation dependent face-to-face communication and interaction processes which are enabled and facilitated by spatial proximity.

Geographical proximity is often combined with other forms of proximity (Boschma 2005, Gertler 2003) such as cultural, institutional or organisational proximity and therefore the impacts can hardly be considered as isolated. This is very significant in cases where knowledge-creating activities took place across national borders in innovation processes. The simultaneous absence of organisational, spatial and also cultural proximity turned out to be very inefficient in innovation projects. Nearly every firm could report experiences on failed projects in the conduction of distant knowledge-creating activities especially across national borders with independent external actors. Thus, in successful projects the lack of spatial proximity was compensated by other kinds of proximity, mostly organisational proximity.

The findings also reveal that the spatial organisation of software firms' innovation processes may not be typified according to a local-global dichotomy. No single firm was acting in distributed innovation processes exclusively on a certain scale - neither locally nor globally. Rather, knowledge interactions processes are characterized by their multi-scalarity. During the innovation process, actors on the regional, national and international scale were included depending on the required complementary knowledge. Even firms acting as *customised solution providers* are not bound to their regional innovation system. These firms also obtain innovation projects of customers in spatial distance through reputation or referrals, because they are considered as experts in a particular knowledge domain. The necessary high level of close in-depth interaction in the innovation process is achieved through arrangements of temporary on-site working phases and replaced by on-site meetings and supported by information and communication technologies. These firms draw mostly on developed organisational models based on procedural knowledge gained in former projects to handle distant knowledge interactions. In all case studies, irrespective of which mode of ODIP was practiced, the dynamic and temporary use of spatial proximity in the process of knowledge production was apparent. The necessity for moments of geographical proximity (Torre 2008) remains of considerable importance in organisationally decomposed innovation processes of the software industry.

Turning to the question of embeddedness we can state that an increasing degree of global division of labour in knowledge production does not necessarily indicate a decrease in the regional embeddedness of a firm. Our results underline the point that these firms who practice highly complex modes of ODIP are at the same time more embedded in global *and* local contexts than other software firms.

Even for the firms of *group 2*, who offshore parts of their innovation processes, evidence for regional embeddedness as well as an international division of labour can be found. While the knowledge-using activities are executed in non-OECD countries, these firms maintain regional/national relations to customers, suppliers and public/private KIBS. There is a pretty clear distinction between knowledge creating actors in OECD countries and knowledge-using activities in non-OECD countries. Also the internationally organised "*innovation process managers*", remain deeply rooted in the innovation system of their home region. The distinctive features of these firms are the independence and autonomy of its offshore subsidiaries, responsible for own customer relations. Global actors have a high significance in their innovation processes, since not only knowledge-using activities are conducted in non-OECD countries, but also activities similar to those of the German headquarter.

Yet this fact did not lead to a diminished significance of relations within the home region of Baden-Württemberg. On the contrary, "cost driven outsourcing firms" and "Innovation process managers" show institutionalized relationships to regional actors like public research organisations, universities, specialized KIBS and lead customers. They have established and invest on a continuous basis in regional knowledge networks which they mobilise in a flexible way in the respective innovation processes. For instance, BS_FIN2 collaborates in dynamic, content-specific contexts with several universities and research institutes. In these cases the content is mainly focused on basic research, concerning software engineering methods and framework generation. Hence, software firms like BS_FIN2 can limit the build up of own, expensive R&D capacities. As pointed out by these firms, without such regional, often highly personalized relations established over time, it would be difficult in innovative projects to get access to necessary expertise and competences in specialized knowledge domains and to combine it a flexible timely manner. Software firms act in highly fluid knowledge markets and have to response to the increasing requirements in software development due to growing complexity and the increasingly different application domains. In turn, firms state an increasing demand for expertise in interdisciplinary knowledge fields combining IT-know-how with vertical and/or horizontal domain knowledge. By providing highly-specialised, knowledge-intensive expertise and comprehensive problem-solving simultaneously, the integration of particular but diverse knowledge fields into one innovative solution constitutes the competitive advantage in developed markets. Particularly software firms of group 3 leverage their innovation system (be it national or regional) and their Global Value Chains to deliver innovative systemic solutions. It seems that headquarters in Baden-Württemberg have gained the organisational capabilities to decontextualise and recontextualise knowledge which is accumulated and located in dispersed sites of the firm and combine it with external knowledge in a flexible way to create a complementary knowledge base.

5.3 Territorial knowledge dynamics – the role of subsidiaries

In the course of the last 10 years in many cases of the analysed firms an evolution of the scope of the capabilities of subsidiaries can be noted. As pointed out in research on MNCs particularly foreign-based subsidiaries are increasingly involved in the use and generation of knowledge (Zanfei 2000, Zander 2002, Frost/Birkinshaw/Ensign 2002). In the case studies of AUTO_IT, COMM_IT and BS_GLOBAL an expansion of capabilities of the Indian subsidiaries is very obvious. Remarkably, these dynamics could even be found in subsidiaries of secondary software suppliers like AUTO_IT and COMM_IT. All subsidiaries were initially established to carry out knowledge-using tasks, being delegated by their headquarters. To date, they are responsible for individual customer-relations and products, in the case of BS_GLOBAL, even for international markets. Capability building is inherently evolutionary in nature and can be understood as a cumulative path dependent process shaped by both internal and external factors (Dosi/Failiro/Marengo 2008, Eisenhardt/Martin 2002, Teece et al. 1997, Teece 2008).

The expansion of the scope of ODIP – which leads to capability upgrading – depends on technological factors fostering and knowledge-related factors limiting the extent of ODIP. While standardization and industrialization eases spatially distributed software development processes through a separation of knowledge using and creating activities, knowledge - the main production factor of software firms – limits ODIP. The process character, context dependence and the social construction of knowledge requires different forms of barriers (cognitive, organisational and cultural) to be overcome for effective learning in knowledge interactions.

While the establishment of communication channels or (temporary) spatial proximity appears not to be a considerable problem nowadays, an in-depth, experience-based understanding of the client's business domains, business processes and needs is required, which is called "customer domain knowledge". The codification of the specific customer domain knowledge implies high transaction costs due to its complexity and origin in frequent in-depth interaction. Especially the conceptual set-up and software architecture as steps prior to the detailed requirements definition are characterised by high demands in customer domain knowledge, causing that these value chain stages are rarely outsourced.

While the cost advantages of non-OECD countries are obvious, the increase of coordination costs due to knowledge-related factors is difficult to account for in firms' **strategic** decision as to whether or not the scope of ODIP should be limited or expanded. They face a trade-off between an increase of cost advantage and flexibility on the one hand and a decrease of development speed and efficiency on the other hand. The implications of ODIP can be very different for software firms due to the idiosyncrasies of their knowledge bases, strategies, products, experiences and organisational structure. Among our cases we found examples for both increase and decrease of costs/speed/flexibility during the decomposition of innovation processes. Yet most certainly, the technological advancement that enables the spatial organisation does *not* lead automatically to the offshoring of innovative activities to non-OECD countries. The following examples of subsidiaries which were able upgrade their capabilities, however, shows how and why the expansion of ODIP may take place.

The debate about the changing role of subsidiaries originally focused on the global division of labour in manufacturing industries and emphasizes the degree of autonomy of subsidiaries as an important internal determinant. A specificity of the software sector is a generally higher degree of autonomy of subsidiaries compared to the ones of manufacturing industries which is grounded in the intangibility and knowledge intensity of the software 'product'. Every development project has a certain degree of novelty and to achieve the final product there is not only one way possible. Instead several problem solving approaches can be chosen, discussed as complementary in software development. To ensure the fitting accuracy of the software product the responsible teams do need context knowledge from their internal or external customers to different extent. Even for projects implying mainly knowledge using activities communication processes are necessary. Compared to their counterparts in manufacturing industries these sector specificities affect the degree of autonomy, the possibilities to learn and to build competence on side of software subsidiaries. Since the subsidiaries act in different contexts, depending on the customers and the respective projects, they have to acquire knowledge from various domains, thus accumulating a knowledge base which in turn is accelerating the upgrading of capabilities on sides of the subsidiary.

The interdependency between capability building and autonomy is visible in the development course of the analysed software subsidiaries. The capabilities and accordingly, the degree of autonomy of the subsidiaries, evolved along the trajectory given in Figure 4 below. Over time, these subsidiaries have been assigned to more and more knowledge-creating tasks such as the development of own products for local and even global markets. With the assignment of subsidiary-led projects and product development the subsidiary gains a certain degree of autonomy.

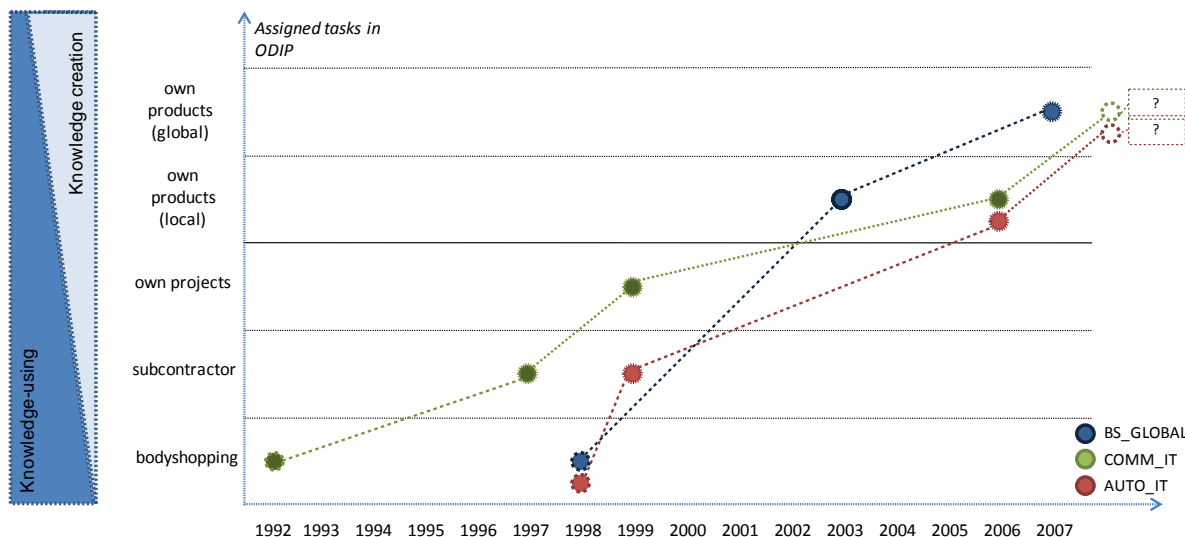


Fig. 4: Evolution of autonomy of Indian IT-subsidaries of German software firms
 Source: Own research

The analysis of patents does also reflect the capability building of subsidiaries, since patents are one of the most important output indicators of the creation of novel technological

knowledge. In the figures below, the patent generation of BS_GLOBAL Bangalore is presented to show its general quantitative dimension (Fig.5) and to examine its degree of autonomy in knowledge production (Fig. 6). The number of patents may not mirror the quality of the knowledge created or the significance of an invention for the actual products of BS_GLOBAL, but it is definitely useful in the analysis of the upgrading of capabilities: The number of patents can indicate the scale of knowledge-creating activities carried out in Bangalore over time. To analyse the patents applied by BS_GLOBAL we acquired the relevant data from the USPTO and the EPO and deleted patents that appeared in both patent offices. Until now (November 2009), BS_GLOBAL Bangalore participated in the application of 72 patents. Yet despite being established in 1998, BS_GLOBAL Bangalore was not involved in any patenting activity before 2002. Between 2003 and 2004, the number of patents, of which Bangalorean employees of BS_GLOBAL have been accounted for, increased rapidly and remained on a high level until 2006.

Furthermore, Fig. 6 confirms that the autonomy of BS_GLOBAL Bangalore has increased as well. The figure below illustrates which share of all patents applied by BS_GLOBAL Bangalore has been invented solely by employees of BS_GLOBAL Bangalore. This may serve as an indicator for knowledge creation activities carried out autonomously by the Bangalore subsidiary in the context of the global division of labour in innovation processes. The level of autonomy of BS_GLOBAL Bangalore increased simultaneously with the rising level of knowledge creation in general. In 2003 the first patents have been applied autonomously, which represent 25% of all patents invented at the location. In the following years, the share of independently applied patents grew to 33% in 2004 and 53% in 2006.

However, learning at offshore locations is not only limited to technological aspects – especially Indian software subsidiaries build up vertical domain knowledge as well as capabilities to bridge cultural gaps in knowledge. As our interviews show, some parent firms have meanwhile established internal organisational routines to foster the bridging of cultural gaps. By developing models of organised geographical proximity (Torre/Rallet 2005) for face-to-face communication and interaction, they support intercultural learning effects aimed to reduce cognitive distance. In the case of AUTO_IT for example the Indian subsidiary has also its own marketing unit in Germany to promote their competences and capabilities to customers within the entire corporation. Internal competition between different subsidiaries appears to be another important internal factor which fosters strategies to stretch out to knowledge creation activities.. The stronger orientation of internal performance measure on intangibles in governance structures of the parent firms sets additional incentives to create inimitable competencies on sides of the subsidiary management. For instance AUTO_IT measured the performance of its subsidiary in India on the number of patents applied per year and the target figures are lifted with the competence building.

Additionally, the empirical analysis in Bangalore underlines the importance of external local factors in capability building. The results underline that the subsidiaries meanwhile have established linkages to external actors, like public and private KIBS or research institutes, located in the regional context. The empowerment of the subsidiaries engaged in knowledge production with a certain degree of autonomy appears to be necessary and in turn fosters the

establishment of external networks. Although the subsidiaries have been still quite dependent from the headquarters, they build up network linkages to the regional institutions and organisations and embed them in their knowledge-creating activities. These linkages can bring them untradeable competencies or advantages in the sourcing of human resources and knowledge. Even in decomposed innovation processes that spread over national borders the embeddedness on both locations low as well as high cost still matters in the software industry.

6. A new geography of innovation emerging?

The paper focussed on the territorial shaping of distributed innovation processes in the software industry. Our findings underline that knowledge dynamics unfolding along such processes have both sector specific characteristics and are often multi-scalar in nature. Software firms do not follow one single mode of ODIP, but practice several different forms of decomposition to different extents. In our sample firms of the German software industry, the majority of activities which are spatially decomposed over national borders are knowledge-using ones. Only a few firms are able to perform complex modes of ODIP in which knowledge-creating *and* knowledge-using activities are delegated to intra- and interorganisational actors. There are several factors preventing or limiting the delegation of knowledge-creating activities to offshore partners. Among those often mutually reinforcing factors are the close connection between knowledge exploration and exploitation, the importance of customer interactions and complex customer domain knowledge. Despite all technological advancements in workflow management, business software or communication, the fact that knowledge is an essential production factor and product of software firms, limits their ability to outsource some parts of the innovation process. Hence, a distinct division of labour of knowledge-creating activities located in OECD countries and knowledge-using activities carried out in non-OECD countries could be noted.

However, ODIP is not static and we doubt that this division of labour is fixed, as we could also find cases which underline the statement of the upgrading of capabilities in non-OECD countries. There definitely is a qualitative shift in some subsidiaries in non-OECD countries, which are able to conduct knowledge-creating activities in innovation processes. Paradoxically this rapid capability upgrading is also caused by the significance of knowledge for the production of software. It implies that subsidiaries of MNCs have to have a higher degree of autonomy than e.g. those of manufacturing industries to carry out even knowledge-using activities. Their participation in several projects requires and builds up cumulative context-dependent knowledge bases. Thus subsidiaries are able to learn in different customer-dependent contexts and can increase their capabilities to create knowledge in innovation processes. A qualitative shift in non-OECD countries is visible and may even accelerate, since the upgrading of capabilities opens up new opportunities for subsidiaries to further participate in innovation processes. Additionally, as our findings indicate software firms in Germany do also foster strategically further competence building.

But there is not only a qualitative shift in non-OECD countries, there is also a qualitative shift in OECD countries which tends to be overseen. Our findings underline that labour division in knowledge production which is required by practicing ODIP has distinct qualities due to the process character, the context dependence and the social construction of knowledge. As suppliers and subsidiaries of MNCs in India upgrade their capabilities, mutual learning effects of German software firms take place. The latter establish organisational capabilities and accumulate procedural knowledge necessary to manage complex modes of organisationally and spatially distributed knowledge production. Without the ability to contextualise, de- and recontextualise the knowledge created on various locations, software firms are not able to gain advantages out of distributed innovation processes. Transferring or replicating such kind of competences from one economic setting to another in a different geographical context may be rather difficult as they seem to be attributable to local forces. Both the competence building of subsidiaries and suppliers in non-OECD countries as well as the formation of organisational capabilities of software firms in OECD countries integrating diverse and highly specialized knowledge bases, seem to be path dependent processes. How these processes are shaped by internal and external factors and co-evolve in their multi-scalarity do need further research. At the moment only the contours of these territorial knowledge dynamics became apparent.

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